DEVELOPMENT OF A SOCIAL WEIGHTS MATRIX TO CONSIDER FRIENDSHIP INFLUENCES ON AIR TRAVEL

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DEVELOPMENT OF A SOCIAL WEIGHTS MATRIX TO CONSIDER FRIENDSHIP INFLUENCES ON AIR TRAVEL

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To my parents and sister – family is forever

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SUMMARY

People often make social-related trips to perform activities with their friends. An individual's group of friends can be characterized by his or her social network. While traditional social network data collection is time-consuming and dependent on memory recollection, new online social networking sites may address these shortcomings. This research focuses on the use of tie-strength, the strength of an individual's relationships in his or her social network, to characterize friendships and how this influences an individual's air travel behavior. Four candidate weighting schemes were developed using data collected from a web-based survey which included demographic information, an air travel diary, and friendship information retrieved from Facebook.com. The candidate weight matrices were then tested in a spatial Durbin count model (social model). The results of this study are threefold. First, candidate weighting schemes which consider mutual friendship (i.e. the number of mutual friends two people have in common) exclusively produced higher log-likelihoods than weighting schemes which also consider whether individuals are direct friends (i.e. whether the two individuals are friends themselves). Second, the results of the social model were compared with those of a non-social model. These results suggest that there exist major flaws in using a non-social model to represent variables which may be socially dependent and correlated. Finally, results suggest that individuals tend to have friends who, on average, make more trips than they do. With a growing number of people using online social networks, exploring and understanding friendship influences on travel behavior will help the transportation industry better recognize future travel needs.

CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

As transportation is a derived demand, people make trips in order to perform activities. Research suggests that people travel to perform social activities with other individuals in their social networks (Berg, Arentze, & Timmermans, 2010a; Carrasco, Hogan, Wellman, & Miller, 2008a; Carrasco & Miller, 2009; Ettema, Arentze, & Timmermans, 2011; Larsen, Axhausen, & Urry, 2006; Moore, Carrasco, & Tudela, 2013; Ohnmacht, 2009; Sharmeen, Arentze, & Timmermans, 2014). An individual's social network consists of people with whom he has relationships. Social networks have been studied in sociology for several decades and research suggests that an individual's behavior is influenced by his friends (Deutsch & Goulias, 2013; Viry, 2012).

Members of an individual's social network are typically determined by using name generator questions which ask the respondent to identify people he considers part of his social network. However, this type of data collection is dependent on the specificity of questions asked and the ability of the respondent to recall people with whom he interacts. Additionally, this type of data collection is very time consuming.

Online social networks, such as Facebook, provide an alternative method of social network data collection that can overcome the shortcomings of traditional methods. As online social networks allow for naturally developing social networks with clear boundaries, respondent recollection is no longer a problem (Axhausen, 2008; Manski, 1993). Additionally, data collection is less time consuming than traditional methods, as

the data can be retrieved from computer databases nearly instantly instead of gradually from respondents' memories during a time-consuming interview process (Axhausen, 2008; Manski, 1993).

Tie-strength is a measure of the strength of relationships in a social network and has been studied for traditional social networks and new online social networks. Understanding and quantifying tie-strength has been researched in both sociology and computer science (Arnaboldi, Guazzini, & Passarella, 2013; Gilbert & Karahalios, 2009; Granovetter, 1973; He, Zhang, & Ji, 2012; Peter V. Marsden & Campbell, 1984; Pappalardo, Rossetti, & Pedreschi, 2012; Shi, Adamic, & Strauss, 2007; Sosa, 2011; Wellman & Wortley, 1990; Zhao, Wu, Feng, Xiong, & Xu, 2011). In traditional social network analysis, tie-strength is assessed during data collection by asking the respondent to determine the relationship strength based on communication frequency and type of relationship. In online social network analysis, tie-strength can be assessed quantitatively by determining communication frequency in various modes, such as mutual photos, wall posts, messages, etc. However, not all of this data is publically available from Facebook.

The objective of this research is to determine a method for representing the intensity of relationships in an individual's online social network, specifically tie-strength, based on limited publically available data. Research suggests that an individual's behavior is influenced by his friends' behavior, and this research studies this influence in terms of air travel behavior using econometric techniques, which have been used previously to quantify peer effects and behavioral influences (Adjemian, Lin, & Williams, 2010; Bramoullé, Djebbari, & Fortin, 2009; Calvó-Armengol, Patacchini, & Zenou, 2009). The contribution of this research is the development of social weights

matrices to characterize the strength of relationships between individuals. An optimal matrix is selected by maximizing the likelihood of a spatial Durbin count model of the number of air trips taken by an individual.

With an increasing number of people utilizing online social networking websites, a large dataset is becoming available that highlights naturally occurring social networks (Lewis, Kaufman, Gonzalez, Wimmer, & Christakis, 2008). Analyzing these datasets can provide insight to an individual's social network which has previously been difficult and time-consuming to understand due to traditional data collection techniques. These datasets can help in researching how an individual's air travel behavior is related to his online social network. This understanding will help transportation professionals address future transportation needs, such as social activity-based travel and airline destination choices.

1.2 Literature Review

1.2.1 Social Networks

Social networks are defined by an individual's relationships with other people. Relationships have three key characteristics: content, direction, and strength (Haythornthwaite, 1996). Content includes the type of information or resources being exchanged in the relationship. Direction is the path of content exchange. Strength refers to amount of content exchanged – suggesting the intensity of the relationship (Haythornthwaite, 1996).

There are two main approaches to analyzing the structure of a social network – egocentric network analysis and whole network analysis. The egocentric network

approach focuses on a single individual (the ego) and his relationships with other people (alters). This approach is advantageous when the social network is large and has ambiguous boundaries. The whole network approach focuses on the relationships between each individual in a network with all other members of the network; this approach becomes difficult with large networks because the number of relationships increases rapidly (Haythornthwaite, 1996).

Researchers frequently define members of a social network by using a set of name generator questions (Berg, Arentze, & Timmermans, 2010b; Degenne & Forse, 1999; P. Marsden, Carrington, Scott, & Wasserman, 2005a). Name generators are questions that solicit information from an individual regarding whom he considers as part of his social network. There are four main egocentric approaches for developing name generators: the interaction approach, the role-relation approach, the affective approach, and the exchange approach (Van der Poel, 1993). The interaction approach focuses on all of the people with whom an individual has a relationship (including casual contacts) within a specific time period. Relationships are characterized based on the number of interactions; however, the importance of the relationships is not characterized. This approach can utilize data from online social networks such as Facebook. The role relation approach records people who have a role relationship with an individual; examples of role relations include family and friends. The affective approach characterizes people based on the importance of their relationships. The exchange approach characterizes individuals based on their social exchanges (Van der Poel, 1993).

1.2.1.1 Social Network Analysis in Sociology

Social network studies in sociology introduce the idea that an individual's status and behavior is affected by his or her peers' status and behavior. There are three main families of social network studies in sociology: the community studies and the social capital approach, the small world approach, and the social network approach. In community studies and the social capital approach, social networks are based on traditional values of kinship and friendship. In the small world approach, all individuals are presumed to be separated by a few intermediaries. In the social network approach, social network structure is described using nodes and links where nodes represent individuals and links represent relationships, either holistically or egocentrically (Berg, Arentze, & Timmermans, 2010c; P. Marsden, Carrington, Scott, & Wasserman, 2005b; Wasserman & Faust, 1994).

As mentioned previously, social network information is typically collected using survey and interview methodologies by asking name generator questions. However, problems with this data collection method can occur when respondents have a difficult time recalling information regarding their social networks (Axhausen, 2008). Additional issues include when researchers attempt to infer whether the average behavior of a group influences the behavior of individuals; it is not possible to make inferences regarding exogenous effects, endogenous effects, or correlated effects (e.g. people with a common environment are likely to behave similarly) unless the researcher has previous knowledge relating to the composition of the reference group (Manski, 1993).

Early social network studies include Bonacich (1972), who discusses methods to determine an individual's status in a clique using the whole network approach; a clique

includes members who have no relationships outside of the clique and are related to members inside the clique directly or indirectly. Bonacich presents three different weighting approaches to calculate popularity status given choices: infinite series convergence, simultaneous linear equations, and the Hubbell method. These methods differ primarily by the degree of friendship allowed. Infinite series convergence method considers only popularity ratings of direct friends. Simultaneous linear equations method considers popularity ratings of direct friends and mutual friends. The Hubbell method considers popularity ratings of members of outside of the clique as well (Bonacich, 1972).

Bonacich (1987) also proposes a measure of centrality, $c(\alpha, \beta)$, which relates to the sum of the individual's connections weighted by their centralities. In this equation, β represents the degree to which an individual's status (i.e. power status, social status, workplace status, etc.) is related to the statuses of his connections. For example, if $\beta = 0$, then the centrality measure is proportional to the number of individual connections, regardless of centrality. If $\beta > 0$, then an individual's power/centrality increases by connections who are also high status. If $\beta < 0$, then an individual's power/centrality increases by connections who are lower status (e.g. in bargaining, it is better to be connected with people who have fewer connections because they have fewer other people to bargain with) (Bonacich, 1987).

Other indices and measures of network data are discussed by Marsden (1990) and include network size, network density, tie-strength, and network range. Network size is defined as the number of nodes and links in a network and is typically used to measure popularity, range, and integration. Tie-strength is typically used in social networks to

measure the strength of individual relationships and is discussed further in Section 1.2.1.4. Network density is the collection of the tie-strength of the connections and is an indication of network structure. Network range indicates the extent of the network and can be measured by network size and inversely by network density (Peter V Marsden, 1990).

Recent social network behavioral studies include Deutsch & Goulias (2013), which discusses the decision roles that different social network members play regarding activity participation. Two separate latent class cluster analysis models were used to analyze data collected using a web-based survey in Santa Barbara, California. Respondents were asked about which members of their social network (i.e. immediate family, extended family, friends, coworkers, students (peers), students (as a mentor), and organizational members) they interact with in a typical week. The first latent class cluster found that there were similarities in terms of size, strength of relationships, and frequency of interaction, among the immediate and extended family social network types as well as the organizations, coworkers, peer students, and mentor students social network types. The second latent cluster found that the decision-making role of an individual is very different across the social network types. Family and friends tend to have more predominant decision-making roles while coworkers and organizational members have a more decision-following role (Deutsch & Goulias, 2013).

Additionally, Viry (2012) studied the link between spatial dispersion of social networks, residential mobility, and social support (i.e. emotional support from family and friends). The study used data from the 2005 Measures and Sociological Observation of Attitudes in Switzerland (MOSAiCH) survey which is a nationwide representative survey

that used a name generator and name interpretation approach. The results show that neither geographical distance of the social network nor residential mobility affect the extent of social support given or received. Additionally, individuals with localized social networks exhibit many of the same social support ties as individuals with long-distance contacts. Individuals with high income and who live in large cities received more social support than lower income suburban individuals. Individuals rooted in friendship networks tend to receive more social support than those rooted in family members and colleagues. The study also showed that distance from the residence at age 14 did not lead to an individual having more fragmented (i.e. sparsely connected) social networks (Viry, 2012).

1.2.1.2 Online Social Networks

Online social networking websites, such as Facebook.com and Twitter.com provide a unique way to observe social network data. Lewis (2008) discusses the five defining features of the Facebook dataset, which is used in this study. First, data from Facebook is naturally occurring when downloaded directly from Facebook.com; this eliminates the issues in respondents' ability to recall certain information and other sources of error in survey research (Axhausen, 2008; Manski, 1993), particularly those that utilize name generator data collection techniques. Second, Facebook.com contains complete network data of a sociocentric nature, as opposed to an egocentric nature. This is advantageous given the interconnectedness of network members and the ability to determine member roles based on peers. Third, Facebook has the ability to provide longitudinal data, such as how relationships grow and change over time. However, such

studies must recognize that once relationships on Facebook are established, they must be actively terminated, which is rare. Fourth, Facebook can provide data on multiple facets of relationships: people tagged in photographs together may represent a stronger relationship than people who are only "friends". Finally, Facebook data can provide some cultural insight as individuals can indicate tastes and values; however, this data is difficult to quantify as responses are generally open-ended and can require significant post-processing. Additionally, in general, privacy settings on Facebook often restrict the ability for researchers to retrieve certain data (Lewis et al., 2008).

1.2.1.3 Travel Behavior

Studies have shown that social networks may influence social activity and travel behavior. However, challenges in data collection have hindered research in this area (Axhausen, 2008; Manski, 1993). Axhausen (2008) discusses current survey challenges and content that needs to be included in travel behavior surveys in order to capture how social network membership and geography influence travel behavior. Survey challenges include the need for new objectives that describe the social purpose of activities, defining the beneficiaries of the activities, and determining the cost of activities to participants and beneficiaries. Current surveys solicit respondent's social networks focused mainly on relatives and primary contacts due to the name generator question structure, which is dependent on memory recollection (Axhausen, 2008). However, with new online social network data, this can be mitigated as individuals do not have to recall relationships from memory (Axhausen, 2008). Additionally, data collection using online social networks

may be faster than traditional interview methods, which are very time consuming (Axhausen, 2008).

Axhausen (2008) further discusses additional content that needs to be included in travel behavior surveys, such as better representation for groups of special interests such as households divided by location (e.g. parents with boarding students, couples working in different cities), households with multiple residential locations (e.g. beach house, home abroad), and immigrant families who travel to other countries to see family; these groups often travel more and have higher travel budgets. Additionally, groups that may be socially excluded include low income or disabled individuals and may be spatially correlated. Obtaining name generators and mobility biographies are difficult (e.g. number of contacts received, burden on respondent, contact description detail, type of social contact). Personal questions regarding social networks make survey administration difficult. Face-to-face interviews best establish trust between interviewer and respondent. Interviews historically take approximately two to three hours; therefore, social network and travel behavior data collection can become very time consuming (Axhausen, 2008).

In a prominent egocentric social network travel behavior study, data were collected as part of the Connected Lives Study in Toronto, Canada and included information regarding an individual's social related travel, the spatial distribution of his social network, and the various modes of communication used (e.g. telephone, email, in-person) (Wellman et al., 2005). Name generator questions focused on the network of people the respondent defined as close and were used in both the survey and interview process. In this study, closeness was used as both a tie-strength measure and a network boundary measure. The hypothesis was that an individual's social network is a key cause

of travel behavior (Carrasco, Hogan, Wellman, & Miller, 2008b). The data was used to discuss two factors that lead people to travel – agency and social accessibility – as related to the respondents' social networks. Social accessibility is defined as the practical constraints of leisure travel; agency is defined as an individual's willingness to plan events with members of his or her social network and overcome constraints. The study found that individuals who live closer together and are more intent on planning events are more able to maintain reciprocal relationships. Additionally, more distant ties require more effort from the individuals to maintain. Close relationships appear to be mutually reinforcing, suggesting that interactions tend to be expected. Individuals with larger social networks or more fragmented social networks tend to be more active, as both of these networks require a lot of maintenance (Carrasco et al., 2008a).

The Connected Lives Study data were also used to do determine the relationship between an individual's social network and social activities, using a social activity-travel generation model (Carrasco & Miller, 2009). The model studied four dimensions of the relationship between the ego's frequency of social activities with each alter: personal characteristics, who the activities were performed with, the composition and structure of the social network, and the information and communication technology interactions. Results show that single males with high incomes have more frequent social activities with network members. Additionally, younger individuals participate in more social activities with other younger people while older individuals interact more with other older people. The number of alters, density, and centrality have a significant effect on frequency of social activities. While telephone communication complements social activities and instant messaging communication substitutes social activities, email

communication appears to complement social activities for closer alters and substitute for more distant alters (Carrasco & Miller, 2009).

In a similar egocentric social network and travel behavior study, Moore (2013) studied the relationship between an individual's attributes and daily social activities' duration, distance, and number of participants. The study used a two-step structural equation modeling approach to analyze data from the Communities of Concepción – data from four neighborhoods in Concepción, Chile. This data were collected during a face-to-face interview. Results suggest that individuals spend more time in a social activity when more members of his or her social network are present and when members are emotionally close. Additionally, individuals with higher incomes are willing to travel farther for social activities (Moore et al., 2013).

Studies have also suggested that changes in social activities and travel behavior may occur after major life events. Sharmeen (2014) used a structural equation model to analyze the dynamics of social networks and life-cycle events and how they affect activity and travel behavior. The study used data from an event-based retrospective questionnaire survey conducted in the Netherlands. Results show that young people (less than or equal to 20 years old) are less likely to lose ties (i.e. social network members) and tend to make new ties after a life-cycle event; young adults (i.e. 21 to 40 years old) are more likely to lose ties and not form new ties compared to the base age group (i.e. 41-60 years old). Seniors (i.e. greater than 60 years old) are more likely to make new ties suggesting a possible increase in free time. Men's activity needs change more than women's and therefore, men tend to make more new ties after a life-cycle event; higher education also increases the activity needs and new ties. Additionally, larger social

networks positively correlate with changes in activity needs and new ties (Sharmeen et al., 2014).

Travel behavior is also affected by the strength of an individual's relationships. Ohnmacht (2009) used data from the MOSAiCH survey, similar to Viry (2012), to analyze the likelihood of having strong-tie relationships based on personal characteristics. Using a binomial logit model, Ohnmacht showed that gender and level of income did not have a significant effect on the number of social trips. Additionally, younger individuals tend to have more strong-tie friends, family, and workmates that live outside of his or her residential community, suggesting that young people are likely to be more socially integrated to regions outside of their residential community. Additionally, one-person households have a higher probability of having nonlocal strong ties suggesting that people who live in one-person households have a more flexible lifestyle which allows them to have increased social travel. Individuals who travel outside their residential region for work and individuals who live in a location other than their childhood location (i.e. location at 14 years old) have a higher probability of maintaining nonlocal strong ties; this suggests that a person's mobility biography impacts the spatial dispersion of his or her social network members (Ohnmacht, 2009).

In a recent study, Wall et al. (2014) explored the relationship between an individuals' online social network and air travel behavior. Data were collected using an online travel diary survey that then interfaced with Facebook.com to collect the hometown cities and current cities of the respondent's and respondent's friends'. Results showed a positive correlation between an individual's air travel and the size and geographic distribution of his Facebook friends (Wall, Macfarlane, & Watkins, 2014).

While this study considers how the location of an individual's friends influences where he may travel, it does not consider the tie-strength of the relationships or how an individual's air travel behavior may be affected by his friends' air travel behavior.

1.2.1.4 Tie-Strength

Tie-strength is an indication of the intensity of a relationship between two individuals. Tie-strength can be associated with closeness, information propagation, and with whom an individual participates in activities, which is related to travel behavior (Peter V. Marsden & Campbell, 1984; Sosa, 2011; Zhao et al., 2011). A study by Marsden & Campbell (1984) shows that an important gauge of tie-strength is closeness; kinship (i.e. a familial relationship) and neighboring (i.e. people who live nearby) are not strong predictors of tie-strength. Marsden & Campbell (1984) identified two alternative facets of tie-strength – the depth of the relationship and the length of the relationship. Time spent in a relationship is a good predictor of the magnitude of tie-strength; however, it is difficult to associate frequency and duration of contact as predictors of tie-strength (Peter V. Marsden & Campbell, 1984).

Studies on tie-strength suggest that it is associated with information propagation and teamwork. Zhao et al. (2011) used an information diffusion model to determine the relationship between tie-strength and information propagation for online social networks. Results showed that information adoption is facilitated by online social networks and that there are no significant advantages for information propagation in selecting ties with higher centralities; randomly selecting ties is more efficient for information propagation than selecting strong ties (Zhao et al., 2011). Sosa (2011) performed a socio-metric study

with web-based survey and interview data of a software firm and determined that strongly tied individuals are more motivated to work together and therefore generate more creative ideas (Sosa, 2011).

Shi et al. (2007) discusses the use of strong ties, determined based on transitivity, to distribute information. Transitive ties are defined as individuals with one or more mutual contacts. Non-transitive ties were removed for two social network data sets, varying the transitivity requirement. Results show that removing non-transitive ties does not affect the majority of the social network. Additionally, the average shortest path for information diffusion only slightly increases with the removal of non-transitive ties suggesting the robustness of strong ties (Shi et al., 2007).

Granovetter (1973) discusses the importance of studying weak ties in social networks. Granovetter suggests that weak ties are more likely to link members of different social groups while strong ties are more likely to link people within certain social networks. A network with only strong ties may lead to fragmentation since the groups are not connected (Granovetter, 1973).

Retzer et al. (2010) determined that intermediate ties are important in inter-organizational knowledge transfer because they link weakly connected groups to the network. A k-means cluster analysis was used to determine a distinct group of intermediate ties; reciprocity was used to determine the intermediate ties from the strong and weak ties at the borderlines after the cluster analysis. Results showed that intermediate ties link key groups of organizations which are well connected with other organizations; however, other research regarding intermediate ties is limited (Retzer, Yoong, & Hooper, 2010).

Recent studies have used features of online social network datasets to determine tie-strength. In an egocentric social network study, Arnaboldi et al. (2013) compared an individual's Facebook friends with his or her offline social network to determine a tie-strength model. Results show that an individual can only maintain a certain number of social relationships on Facebook, which is close to the number of offline social relationships an individual can maintain, referred to as Dunbar's number (150 ties) (Arnaboldi et al., 2013). Pappalardo et al. (2012) found that tie-strength is directly related to the number of online interactions between individuals and the number of different contexts used. This study was based on a multidimensional definition of tie-strength using data from Foursquare, Twitter, and Facebook (Pappalardo et al., 2012).

Gilbert et al. (2009) developed a predictive linear model for tie-strength using social media data to distinguish between strong and weak ties. The study used data from Facebook and interviews. The model considered seven categories of variables to represent tie-strength:

- Predictive intensity variables (e.g. wall posts, inbox messages),
- Intimacy variables (e.g. number of friends, photos together),
- Duration variables (e.g. days since first communication),
- Reciprocal services variables (e.g. applications in common),
- Structural variables (e.g. number of mutual friends, groups in common),
- Emotional support variables (e.g. positive and negative emotion words),
- Social distance variables (e.g. age difference, educational difference, political difference).

Results are statistically significant and show that, based on the dataset (n=35), social media can be used to predict tie-strength. This research also suggests that social media could make adaptive privacy controls based on tie-strength (e.g. viewing photos requires higher tie-strength) (Gilbert & Karahalios, 2009).

In a similar study, He et al. (2012) used a multivariate stepwise linear regression (MSLR) to model tie-strength in Sina Micro-blog, a Chinese online social network similar to a hybrid of Twitter and Facebook. The model determined four key dimensions of tie-strength: contact frequency, intensity, intimacy, and reciprocity. Contact frequency includes retweeted statuses, commented status, and private messages. Intensity includes the number of common followers, groups, tags, and interests. Intimacy includes the number of days since last communication, mentioned statuses, and emotions in comments and retweets. Reciprocity includes an individual's number of followers and statuses. Results show that intimacy is the best estimator of tie-strength, and includes the two most significant features – days since last communication and mention statuses (He et al., 2012).

As there is no consistent tie-strength measure across studies and tie-strength actually measures multiple dimensions of social networks, Rosen (2011) suggests a reconceptualization of tie-strength to "tie-utility", which provides a multidimensional taxonomy allowing researchers to frame tie measures for their specific needs. Tie-utility represents the three main dimensions of social networks – socio-emotional closeness, resource potential, and accessibility. These three dimensions allow for tie-strength measures to be compared among different approaches (Rosen, 2011).

1.2.2 Tools of Econometrics

Econometric models have been used to show behavior similarity. A study by Bramoullé (2009) presented a linear-in-means model[1] with endogenous and exogenous social effects in a social network. The study used data from the Add Health survey which indicates use of recreational services by secondary school children (Harris et al., 2009). The study found that students who have active friends tend to be more active themselves. The paper also concludes that while there are many benefits of network data analysis, data collection may be expensive (Bramoullé et al., 2009). Using the same dataset, Calvó-Armengol (2009) found that an individual's school performance is affected by his or her peers' school performance suggesting that students who do well in school have friends who also do well in school (Calvó-Armengol et al., 2009). These two studies indicate that an individual has similar behavior as his peers and suggests that behavior may be influenced by peers' behaviors.

Spatial econometric models are traditionally used to model spatial interdependence between variables. Adjemian et al. (2010) used a spatial Durbin model (SDM) to show the spatial effects of vehicle ownership. Results showed that vehicle ownership is spatially dependent for both the household and the regional level. An OLS model was also analyzed and showed inconsistent results compared to the SDM model, since the data shows spatial dependence (Adjemian et al., 2010).

While spatial models are typically used to model spatial interdependence of variables, this study will use the spatial Durbin model to represent the social interdependence of air travel behavior. Spatial models are appropriate for this study's

[1] A linear-in-means model represents the idea that an individual's behavior is influenced by average behavior of his peers. It is similar to the spatial autoregressive model and allows for exogenous effects.

type of analysis as their weights matrices indicate the strength of the spatially related variables; in this study, the weights matrix is used to represent the tie-strength of individuals' social networks.

1.3 Econometrics of Spatial Modeling

1.3.1 Spatial Model Use

Spatial models are used when variables are spatially dependent or spatially correlated. In a traditional linear regression model,

$$y = X\beta + \epsilon \qquad (1)$$

an ordinary least-squares estimator of $\hat{\beta}$ which estimates values for β – the effect of dependent variable y given the independent variable x. The estimator $\hat{\beta}$ is given by

$$\hat{\beta} = (X'X)^{-1} X'y \qquad (2)$$

Assuming that the residuals ϵ are independently and identically distributed about a normal distribution with mean zero and variance σ^2, the expected value of $\hat{\beta}$ is unbiased and the variance of $\hat{\beta}$ is $\sigma^2 (X'X)^{-1}$. However, when variables are spatially dependent or correlated, this assumption does not hold; therefore, the estimates are not correct (LeSage & Pace, 2009).

A full treatment of spatial econometrics and models is given by LeSage and Pace (2009), and an overview in a transportation context by Macfarlane (2014, Chapter 3).

1.3.1.1 Spatial Dependence

Spatial dependence is caused when the dependent variable is autocorrelated. A spatial autoregressive model (SAR) can account for this dependence through a spatial lag of the dependent variable (Anselin, 1988). In a spatial autoregressive model,

$$y = \rho W y + X\beta + \epsilon \quad (3)$$

$$y = (I - \rho W)^{-1} (X\beta + \epsilon) \quad (4)$$

a weights matrix, W, is introduced to consider the strength of the relationship between elements. Weight matrices are discussed further in Section 1.3.2.

1.3.1.2 Spatial Correlation

Similar to spatial dependence, spatial correlation occurs when the error terms are spatially correlated, which causes inaccurate standard errors if the traditional linear model is used. A spatial error model (SEM) addresses this problem and is as follows:

$$y = X\beta + u \quad (5)$$

$$u = \lambda W u + \epsilon \quad (6)$$

$$y = X\beta + (I - \lambda W)^{-1} \epsilon \quad (7)$$

1.3.1.3 Spatial Durbin Model (SDM)

The spatial Durbin model (SDM) considers both spatial dependence and spatial correlation, addressing both the spatially correlated dependent variable and error terms. The model,

$$y = \rho W y + X\beta + WX\gamma + \epsilon \quad (8)$$

$$\gamma = -\lambda\beta \quad (9)$$

is a linear combination of the SAR and SEM. The SDM is particularly appropriate for modeling systems where elements of the system interact with one another, such as social networks.

A spatial Durbin count model was selected for this study to analyze the variables as they relate to the number of trips an individual makes (see Section 2.3.3). As a count model predicts the conditional mean $\lambda_i = e^{X_i\beta}$ based on a Poisson-distributed process, the social lag variables are considered by suggesting that $\lambda_i = e^{\rho W_i y + X_i\beta + W_i X_i \gamma}$. Previous literature on spatial count models include Bhat et al. (2013), which used a spatial Durbin count model to consider the relationship of several variables on the number of new business on a county level in Texas (Bhat, Paleti, & Singh, 2013).

1.3.2 Spatial Weights Matrices

A spatial weights matrix is an $n \times n$ matrix that indicates the strength of the relationship between each element of the dependent variable with each other element of the dependent variable.

There are many different weighting methods. A simple binary weights matrix would indicate zero if the two elements are not considered connected and one if the two elements are considered connected. Other weighting methods in spatial econometrics include k-nearest neighbors, inverse distance, and fixed distance. K-nearest neighbors considers the number of neighbors regardless of distance. Inverse distance considers the distance between neighbors, which assigns stronger weights (based on distance) to closer neighbors. Fixed distance considers neighbors within a specified distance of an

observation. Candidate weighting schemes for this research are discussed in Section 2.3.2.

1.3.2.1 Row-Standardization

Row-standardization of weight matrices is a standard technique used in econometric modeling. In row-standardization, each element of the weights matrix is divided by the sum of the elements in that row; therefore, each row in a row-standardized matrix sums to one.

The purpose of row-standardization is to create proportional relationships for each element. Often, the number of relationships for each element of the dependent variable is different, so row-standardization normalizes the relationships. Row-standardization creates relative weights for relationships instead of absolute weights, which is advantageous when elements of the dependent variable have a varying number of relationships. If the matrix is not row-standardized and an element has few relationships compared to other elements, the effects of that element will not be shown in the model. For example, in this study, if the matrix is not row-standardized and one individual has many more friends than another individual, the effects of the individual with more friends may mask the effects of the individual with fewer friends and the results may be skewed. However, a disadvantage of row-standardization is that if an element has many more relationships than another element, the strength of each relationship is reduced since each row will sum to one.

CHAPTER 2

DATA AND METHODOLOGY

2.1 Data Collection and Structure

This study focuses on the relationship between an individual's social network and his air travel. To examine this relationship, air travel data from interconnected social networks is necessary. Researchers recruited participants from the Georgia Tech fraternity and sorority system, in partnership with the Georgia Tech Dean of Students, Office of Greek Affairs. A web-based survey instrument hosted by the Georgia Institute of Technology's School of Civil & Environmental Engineering was distributed to a sample population of approximately 3300 Georgia Tech undergraduate students and alumni. The survey was distributed via email to the primary points of contact for each fraternity and sorority on file at the Office of Greek Affairs; fraternities and sororities were asked to also solicit responses from their alumni. The fraternities and sororities were incentivized with a monetary contribution to a charity of their choice, made in their name. A $500 contribution was awarded to both the fraternity and the sorority with the highest number of survey respondents.

The online survey instrument was adapted from one developed for a previous survey (Wall et al., 2014), and contains three components. The first component collected respondents' air travel information from the past year shown in Table 1. The second component collected socio-demographic information from the past year shown in Table 2. The third component asked respondents to log in to their Facebook accounts, and the survey program automatically collected information regarding the hometown city and

current city of the respondent and the respondent's friends, shown in Table 3. This information was collected using a program that interacts with Facebook through the Facebook application programming interface (API). When respondent and friend data were collected from the Facebook API, each person was assigned a unique string identifier associated with their unique Facebook page ID using a one-way hash function (a one-way encryption of the individual's unique ID assigned by Facebook) to secure anonymity. This allowed researchers to determine if a unique friend ID is associated with one or more respondents, while maintaining that individual's anonymity.

The data collected from the respondent's Facebook profile were limited by the respondent's and respondent's friends' privacy settings. Privacy settings prevented the survey instrument from collecting data indicating friendship, hometown location, and current city location from certain individuals with more restrictive settings. Additionally, as privacy settings are a personal setting, friend connections may be indicated as one-way in the data even though one-way friend connections are not possible on Facebook.

Table 1: Air Travel Data Items and Value Ranges, adapted from (Wall et al., 2014)

Air Travel Data Item	Value Range
Trip ID	Unique numeric identifier
User ID	Unique numeric identifier
Departure Date	Month/Day/Year
Trip Length	0 to 14+ nights
Trip Type	One-Way Trip
	Round-Trip
	Multi-Destination Trip
Trip Purpose	Business
	Personal/Leisure
	Both
Origin Airport Code	Airport Code
Origin State	State/ Province
Origin Country	US, Cananda
Destination Airport Code	Airport Code
Destination State	State/ Province
Destination Country	US, Cananda
Other Major City Visited 1	Airport Code
Other Major City Visited 2	Airport Code

Table 2: Socio-Demographic Data Items and Value Ranges, adapted from (Wall et al., 2014)

Socio-Demographic Data Item	Value Range
User ID	Unique numeric identifier
Age	18 to 100 years
Gender	Male/ Female
Race	White
	Asian
	African American
	Hispanic
	Multiple
	Other
US Citizenship	Yes/ No
Education	None
	High School
	Some College
	College Graduate
	Graduate or Professional Degree
Income	$0 to $9,999
	$10,000 to $19,999
	$20,000 to $ 29,999
	$30,000 to $39,999
	$40,000 to $49,999
	$50,000 to $59,999
	$60,000 to $69,999
	$70,000 to $79,999
	$80,000 to $89,999
	$90,000 to $99,999
	$100,000 to $149,999
	$150,000 to $199,999
	$200,000 to $249,000
	Greater than $250,000

Table 3: Facebook User and Friend Data Items and Value Ranges, adapted from (Wall et al., 2014)

User Data Item	Value Range
User FB ID	Unique string identifier
Birth date	(Month/Day/Year), (Month/Day), NULL
Survey Completion Timestamp	Time, Month, Day, Year
Completion Indicator	Binary Indicator
Hometown Location	(City), (City, State), (City, State, Country), NULL
Current City Location	(City), (City, State), (City, State, Country), NULL
Friend List Size (Total)	Number
Friend List Size (Collected)	Number
Friend Data Item	**Value Range**
Friend ID	Unique numeric identifier
Friend FB ID	Unique string identifier
User ID	Unique numeric identifier
User FB ID	Unique string identifier
Hometown Location	(City), (City, State), (City, State, Country), NULL
Current City Location	(City), (City, State), (City, State, Country), NULL
Birth date	(Month/Day/Year), (Month/Day), NULL

2.2 Survey Response

2.2.1 Respondents

A total of 92 individuals participated in the study; however, only 56 respondents completed the third component of the survey (the Facebook data collection)[2]. Descriptive statistics of the survey respondents are shown in Table 4. The oldest survey respondent was 55 years old while the youngest respondent was 18 years old; the median age is 20 years old. Four respondents indicated they were a college graduate or had a graduate or professional degree; 52 respondents are currently undergraduate students.

[2] In total, 196 individuals filled out the survey; however, researchers discovered an error in the Facebook data collection step of the survey instrument approximately one week after the survey opened. After the error was corrected, 92 individuals began the survey with 56 respondents completing the survey. The data collected from the first 104 individuals was disregarded due to incompleteness.

Table 4: Descriptive Statistics of Survey Responses

User Data	
Respondents (Total)	**92**
Respondents with Facebook (All)	56
Respondents with Facebook (OK Privacy)	56
Oldest Respondent (years)	**55**
Youngest Respondent (years)	**18**
Average Age (years)	**20.6**
Median Age (years)	**20**
Friend Data	
Total Collected	**37,519**
Hometown Provided	33,082
Current City Provided	35,499
With at least One U.S. Location	36,797
Number of Unique U.S. Locations	**3264**
Trip Data	
Total Trips (All Types)	**97**
Round Trips	76
Multi-Destination Trips	1
One-Way Trips	20
Average Trips per Respondent	**1.73**
Trip Purpose Types	
Business	10
Personal/Leisure	76
Both	12
Unique Airports Visited	**48**
U.S. Airports	43
Canadian Airports	1
International Airports	4
Individual U.S. and Canadian Destinations	**93**

2.2.2 Trips

Of the 56 respondents, 44 had made air travel trips over the past year; the most trips made by a single individual is 13 trips. The average number of trips per respondent is 1.73 trips. As this research focuses on air trip destinations to discuss the relationship

between where an individual travels on leisure trips and number of friends the individual has at that destination, and because the survey population was largely US-centric, this study considers only U.S. and Canadian destinations (international destinations were eliminated from the analysis).

2.2.3 Friends

The survey collected friend connection information for 37,519 friends of the 56 survey respondents. The average number of friends per individual is 805 friends. The respondent with most friends had 1,995 friends while the respondent with the fewest friends had 209 friends. Of the friendship information collected, 36,797 friends indicated a U.S. location as either their hometown location or their current city location; of these locations, 3,264 were unique U.S. locations.

The four types of friend connections that could be determined from the Facebook data collected in this survey are: (1) direct friends only, (2) mutual friends only, (3) direct friends with mutual friends, and (4) no relationship. Direct friends only is defined as the two individuals being friends, as indicated by existing on each other's friends list on Facebook, and having no other friends in common. For the purpose of this research, only survey respondents who are friends with other respondents and have no mutual friends in common are considered "direct friends only". "Mutual friends only" is defined as two individuals not being direct friends, but having friends in common. From the survey data, mutual friends are determined by a friend existing on the friends list for both survey respondents. For the purpose of this research, only first order mutual friends are considered. "Direct friends with mutual friends" is defined as two individuals who are

direct friends and also have other friends in common. "No relationship" is defined as two individuals that are not direct friends nor have mutual friends.

2.3 Methodology

2.3.1 Data Post-Processing

The data were post-processed and analyzed using R statistical programming language (R Core Team, 2014); the analysis code is available from the author. Only data from respondents that completed the entire survey (i.e. the air travel diary, socio-demographic section, and the Facebook data collection) were considered for the analysis.

The study analyzes respondents' friends who do not consider Atlanta, Georgia as their hometown. Friends' hometown cities were geocoded as point locations using ArcGIS 10 (ESRI, 2014). While most hometown cities were geocoded by matching the location names with a list of locations retrieved from a previous study (Wall et al., 2014), researchers manually geocoded approximately 2% of cities that were not recorded previously. To associate cities with the Atlanta metropolitan region, Hartsfield-Jackson Atlanta International airport was considered a centroid and circular buffers were created at 25 mile radius increments from 25 miles to 150 miles. Results of the buffer analysis include a list of city locations that are considered for each of the 6 buffer radii. Using R statistical programming language, the number of friends who indicated their hometown city location as being within each buffer region was determined.

2.3.2 Candidate Weighting Schemes

Several weight matrices were developed and then implemented in R statistical programming language to show the tie-strength relationship between survey respondents. Matrix dimensions are 56 by 56 to show a tie-strength for each pair of respondents. Based on the data collected and previous literature, four weighting schemes were considered: binary, number of mutual friends, percentage of mutual friends, and direct mutual relationships. Full matrices and row-standardized matrices used for analysis are shown in Appendix A.

2.3.2.1 Binary

The binary weights matrix is adapted from basic spatial econometric weighting schemes (LeSage & Pace, 2009). The binary weights matrix only considers whether an individual is direct friends with another individual, and only considers the relationships between survey respondents. If two respondents are direct friends, their relationship is indicated by a value of one in the matrix; if the two respondents are not direct friends, their relationship is indicated by a value of zero in the matrix:

$$Binary\ Matrix \begin{cases} 0, & Respondents\ A\ and\ B\ are\ not\ friends \\ 1, & Respondents\ A\ and\ B\ are\ friends \end{cases}$$

Ideally, the matrix should be symmetric prior to row standardization (i.e. if respondent A is friends with respondent B, then respondent B is also friends with respondent A). However, due to the possibility of asymmetric privacy settings on Facebook, the matrix was not symmetric. For example, if respondent A has more

restrictive privacy settings than respondent B, then the survey instrument would be able to access data in respondent A's Facebook account that indicates respondent A and respondent B being friends; conversely, when respondent B completes the survey, the survey instrument may not be able to access similar data indicating their friendship due to stricter privacy settings of respondent A. This privacy restriction affected approximately 10% of the relationships in the sample. However, symmetry was assumed for this matrix as Facebook does not distinguish relationship directionality; the binary matrix was manipulated to be symmetric. All survey respondents were friends with at least one other survey respondent.

2.3.2.2 Number of Mutual Friends

Existing literature discusses tie-strength as a function of mutual friendship (Gilbert & Karahalios, 2009; He et al., 2012). The number of mutual friends matrix considers the number of friends that two respondents have in common, regardless of whether or not the two respondents are direct friends. The number of mutual friends was determined by counting the number of unique friend Facebook IDs that are in common between two respondents' friends lists.

Based on the dataset, this matrix was symmetric prior to row-standardization (i.e. respondent A's mutual friends with respondent B are the same as respondent B's mutual friends with respondent A). This supports that privacy settings may be the cause of the asymmetry as seen in the binary matrix. In this dataset, mutual friends' privacy settings likely affect both respondents in the same manner, therefore causing this matrix to be symmetric. However, it should be noted that this may not be true for other datasets as

individuals can classify friends into different groups on Facebook and apply different privacy settings for each group.

2.3.2.3 Mutual Friend Percentage

The mutual friend percentage matrix is adapted from a cohesiveness measure used in Adamic (2003). The cohesiveness measure used a ratio of the connecting links divided by the total number of links possible (Adamic & Adar, 2003). The mutual friend percentage weights matrix considers only the number of friends the two respondents have in common. Mutual friend percentage is calculated by dividing the total number of mutual friends by the sum of the total number of friends of both respondents.

$$Mutual\ Friend\ Percentage = \left(\frac{\#\ of\ Mutual\ Friends}{\sum \#\ of\ Friends}\right)$$

Based on the dataset, this matrix is also symmetric prior to row-standardization for the same reasons as discussed above. However, as before, this symmetry may not always be observed in future datasets.

2.3.2.4 Direct and Mutual Friend Percentage

The direct and mutual friend percentage weights matrix is a combination of the binary matrix and the mutual friend percentage matrix, and considers whether or not the respondents are direct friends and also whether or not the respondents have mutual friends. This matrix adds a bonus to the mutual friends percentage matrix if the two respondents are themselves friends.

$$Direct\ Mutual\ Matrix \begin{cases} \frac{\#\ of\ Mutual\ Friends}{\sum \#\ of\ Friends}, & Respondents\ A\ and\ B\ are\ not\ friends \\ 1 + \frac{\#\ of\ Mutual\ Friends}{\sum \#\ of\ Friends}, & Respondents\ A\ and\ B\ are\ friends \end{cases}$$

This matrix is not symmetric prior to row-standardization as the binary matrix is not symmetric (as discussed above). Similar to the binary matrix, symmetry was assumed and the matrix was manipulated to become symmetric.

2.3.3 Statistical Methodology

The relevant variables are analyzed using a spatial Durbin count model. The dependent variable being considered is the number of trips an individual takes within a one year period. Building off of a previous study done by Wall et al. (2014), independent variables being considered include several demographic variables (see Table 5) as well as the number of friends an individual has who do not list cities near Atlanta, Georgia as their hometown. The number was determined for the six buffer regions from Hartsfield-Jackson Atlanta International Airport as described in Section 2.3.1. As business trips were excluded from the analysis and the study population was undergraduate students, researchers presumed the primary purpose of travel was to visit family and friends, and therefore friends away from Atlanta were considered an important reason to travel. Additionally, Wall et al. (2014) found that there was a strong positive correlation between greater travel and more disperse (i.e. non-proximate) social networks (Wall et al., 2014).

Each weight matrix was row-standardized and used to create lag variables (i.e. $Wy,\ WX_i$) to be considered in the models. For each weights matrix, seven models were considered: a base model (including all dependent variables except number of friends not from Atlanta) and one model for each of number of friends not from Atlanta based on the six radii. The optimal matrix was determined by selecting that which produces the maximum log-likelihood.

Table 5: Count Model Variables

Independent Variable	Trip Count
Dependent Variables (Respondent - Specific)	Age
	Gender
	Race
	Income
Dependent Variables (Respondents - General)	Friends' Trip Count
	Friends' Age
	Friends' Gender
	Friends' Income
	Friends' Race
Dependent Variables (Respondents and Respondents' Friends)	Number of Friends who do not live within 25 miles of Atlanta
	Number of Friends who do not live within 50 miles of Atlanta
	Number of Friends who do not live within 75 miles of Atlanta
	Number of Friends who do not live within 100 miles of Atlanta
	Number of Friends who do not live within 125 miles of Atlanta
	Number of Friends who do not live within 150 miles of Atlanta

CHAPTER 3

ANALYSIS AND RESULTS

3.1 Weights Matrix Selection

Candidate weight matrices were evaluated on the count model's log-likelihood. Model log-likelihoods are plotted in Figure 1. Each candidate weights matrix is indicated in the figure by a different colored line; the solid lines represent count models where the number of friends not from Atlanta are considered as absolute numbers, while the dotted lines represent count models where the number of friends not from Atlanta is considered as a percentage of the respondent's total friends.

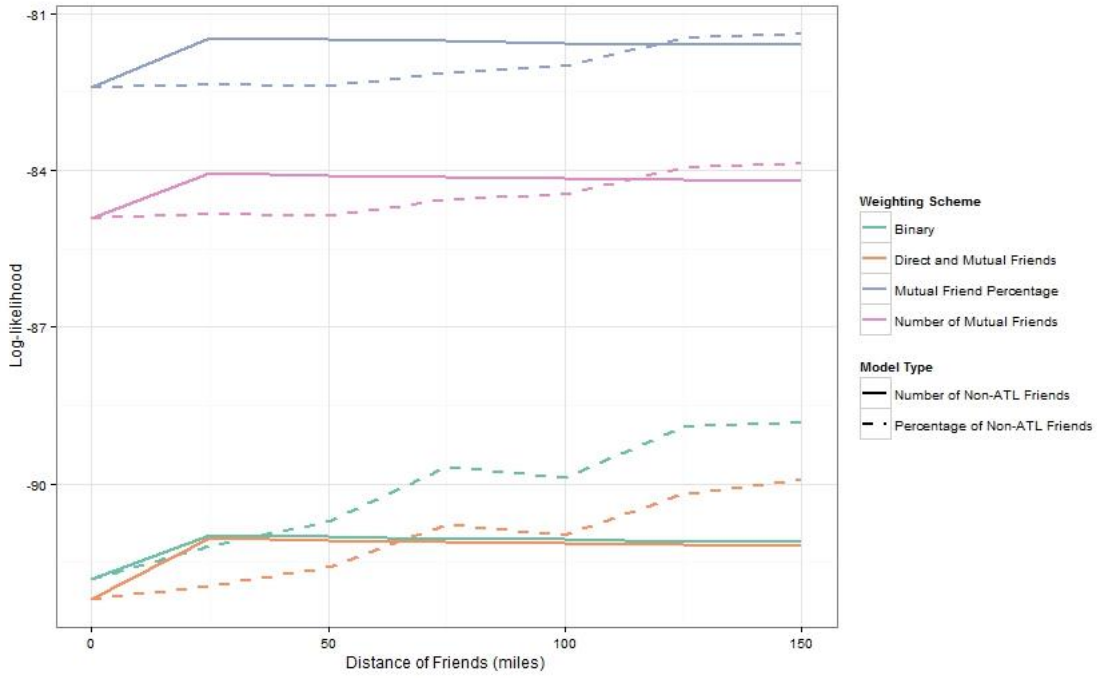


Figure 1: Log-likelihoods for Candidate Weight Matrices Count Models

Optimal model likelihood occurs at a buffer distance of 25 miles using the mutual friend percentage weights matrix. Based on Figure 1, the mutual friend percentage weights matrix and the number of mutual friends weights matrix produce the highest log-likelihoods in the count models (both for absolute and percentage of non-Atlanta friends). This is interesting as it suggests that direct friendship is not as important as having mutual friends; both matrices which consider direct friendship have lower log-likelihoods. The binary matrix and the direct and mutual friends matrix have very similar log-likelihoods, which may be due to the binary component (indicating direct friendship) of the matrix influencing the model more than the mutual friend component.

Figure 1 also suggests that the six distance buffers used to consider the number of friends not from Atlanta have negligible effects on the log-likelihood of the model compared to the weight matrix selection. Using percentage of non-Atlanta friends as opposed to number of non-Atlanta friends produces higher log-likelihoods at larger buffer radii.

3.2 Comparison of Non-Social Models and Social Models

The optimal weights matrix used to characterize friendships is the mutual friend percentage matrix. The spatial Durbin count model (social model) results for this matrix are shown in Table 6 along with results of a model where the social influences are not considered (non-social model). It should be noted that the dataset is not a representative sample of the population; however, the impacts of not considering social influences can still be seen in the results. Results show that, for this dataset, the non-social model and the social model indicate different variables as significant. While the non-social model

indicates that an individual's gender influences his trip count, the social model shows that it is actually the gender of his friends that has an influence on trip count. Similarly, the non-social model suggests that an individual's income and non-Atlanta friends impact the number of air trips made annually. When social influences are considered, the model no longer shows those variables as being important. Instead, variables such as the individual's race and his friends' trip count and income show a strong influence on the number of air trips made by an individual.

Table 6: Count Model Results

	Non-Social Model			**Social Model**		
	Estimates	Std. Error		Estimates	Std. Error	
Intercept	0.375	0.931		1.136	21.47	
Respondent's						
Age	-0.040	0.028		-0.155	0.033	***
Gender (M)	-0.658	0.255	**	-0.475	0.477	
Race (Minority)	-0.737	0.596		-3.273	0.901	***
Log(Income)	0.174	0.098	.	0.113	0.122	
Non-Atlanta Friends (25 Miles)	-6.40E-04	3.84E-04	.	-0.001	4.43E-04	
Social Lags						
Trip Count				-3.069	0.653	***
Age				0.605	0.888	
Gender (M)				-6.678	0.397	***
Log(Income)				-0.166	1.644	***
Race (Minority)				-28.650	6.870	

Significance Codes: ' . ' 0.1 ' * ' 0.05 ' ** ' 0.01 ' *** ' 0.001

The research also explored the relationship between the frequency of an individual's air trips compared to the frequency of his friends' air trips. All four candidate weights matrices were considered in examining this relationship. The matrices which only consider mutual friendship (i.e. number of mutual friends, mutual friend

percentage) and produce the highest log-likelihoods in the spatial Durbin count model show that an individual's friends make slightly more air trips than the individual on average; matrices that consider direct friendship (i.e. binary, direct and mutual friends) indicate that that individual travels slightly more than his friends do.

Figure 2 shows the trip frequency relationships under the candidate weighting matrices as kernel density plots. The figure suggests that on average, an individual makes fewer trips than his friends. This is an interesting result, suggesting that an individual's friends make more trips than himself. This correlates to Feld's friendship paradox, which states that there will always be someone more popular than the individual in his social network (Feld, 1991). The study results suggest that in an individual's social network, there will be someone who travels more.

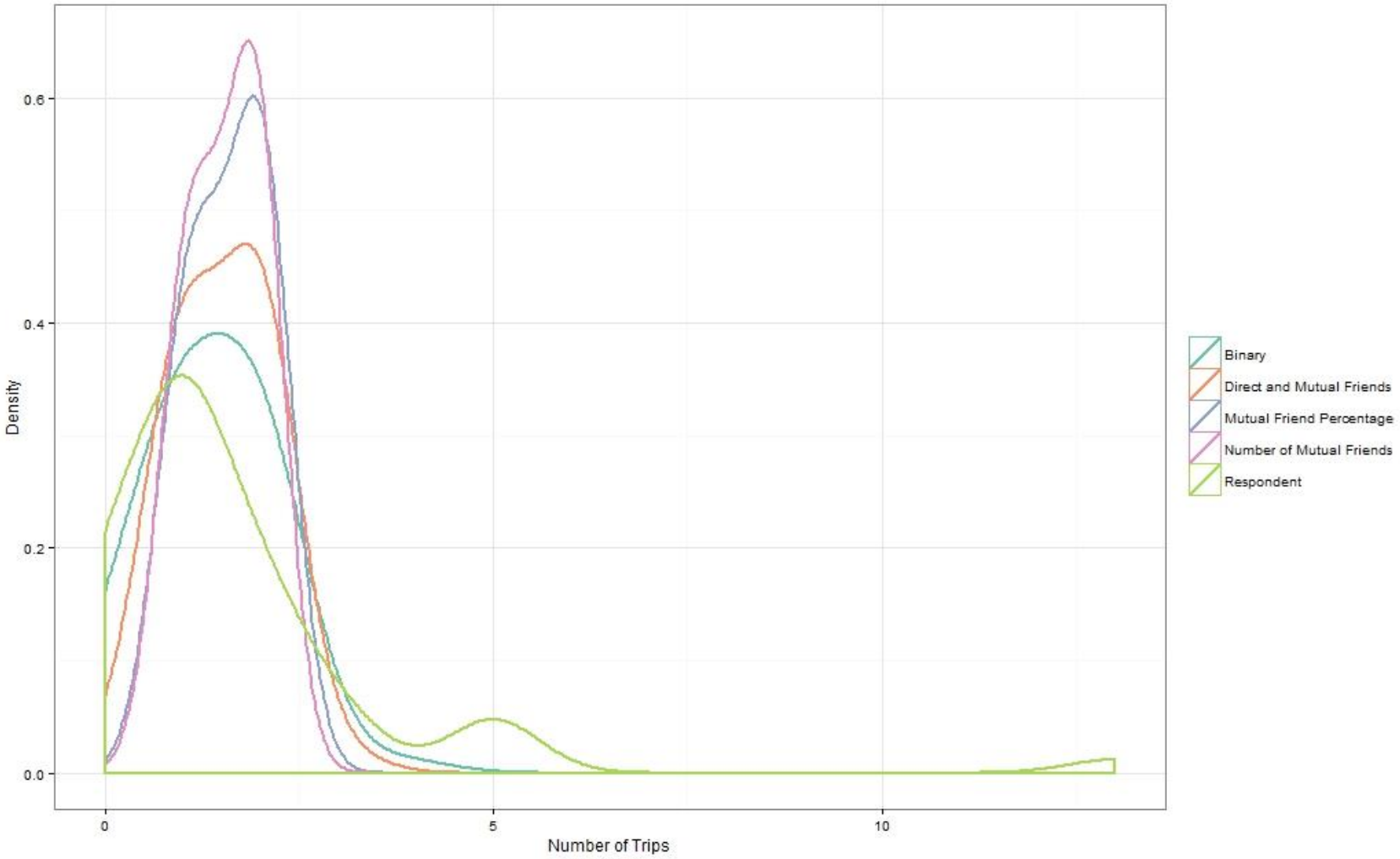


Figure 2: Trip Frequencies of Friends by Weighting Scheme

CHAPTER 4

CONCLUSIONS, LIMITATIONS, AND FURTHER RESEARCH

4.1 Conclusions

This study explores the use of social tie-strength in characterizing the relationship between the air travel behavior of an individual and characteristics (including interdependence) of his online social network. Four different tie-strength weighting schemes were developed using data collected from an online survey that was distributed to the Greek system (fraternities and sororities) at the Georgia Institute of Technology. The survey instrument collected individuals' air travel diary and Facebook account friendship data. The candidate weight matrices were tested using a spatial Durbin count model, and relationships between individuals' trip frequencies and social network characteristics were determined. Three major conclusions arise out of this study.

First, out of the four candidate weighting schemes, the percentage of mutual friend weights matrix produces the highest log-likelihood in the spatial Durbin count model, based on the data collected. This weighting scheme is determined by dividing the number of mutual friends between two individuals by the total number of friends of the two individuals. Additionally, the log-likelihoods suggest that the number of mutual friends that two individuals share is a more important indication of tie-strength than whether the two individuals are direct friends, as the two matrices which consider mutual friends exclusively produced higher log likelihoods than the matrices which also consider direct friendship. The results also show that if the optimal matrix is selected, the difference in the buffer radii distance used to consider the number of non-Atlanta friends

is negligible in terms of model log-likelihood. This result suggests that based on the dataset, the percentage of mutual friends provides the best indication of the tie-strength between two individuals.

Second, the comparison of the non-social model with the social model indicates that if social influences are not taken into consideration, incorrect conclusions may be drawn. The non-social model suggests that an individual's gender influences the number of air trips he takes annually, while the social model indicates that it is actually the gender of the individual's friends that influences the trip count.

Third, the results suggest that an individual will have, on average, friends that make more trips than himself in his social network, which reflects the theory of Feld's friendship paradox (there will always be someone more popular than the individual in his social network). This result suggests that an individual's social network tends to include people who travel more than himself, indicating that people who travel more are likely to have a social network with other individuals who travel frequently.

As more people utilize online social networking websites, there is a growing dataset that is becoming available, which highlights naturally occurring social networks. Exploring these datasets can provide rich insight into an individual's social network that is difficult and time-consuming to obtain through traditional data collection techniques. Utilizing these datasets to study how an individual's air travel behavior is related to his online social network will help researchers better understand social activity-based travel and airline destination choice, which will help transportation professionals address future transportation needs.

4.2 Data Limitations and Constraints

The study is limited by the size of the dataset. Due to time constraints, the survey was released for two weeks at the end of the Spring 2014 semester to Georgia Institute of Technology students who were members of fraternities or sororities. The low response rate may be associated with the time frame in which responses were solicited; the end of the academic term is typically a busy period for students due to final examinations and projects. The sample population is not representative of the general public, as undergraduate students have lower incomes which may cause them to travel less than desired. These limitations may bias the dataset, as most respondents made fewer than five social trips per year; most of these trips were to the respondents' hometowns.

Additional constraints include Facebook policies. Information collected from Facebook accounts using the survey instrument was limited by the data that were accessible via the Facebook API, and was therefore also constrained by individuals' Facebook account privacy settings. These data only allowed for one-degree removed friendships to be determined (i.e. friends of friends). Additionally, the survey did not collect other types of information (e.g. number of wall posts or pictures tagged together) that may be useful in determining tie-strength. The collection of these types of information will be discussed in future research.

Furthermore, air travel history data collection is time-consuming and limited by respondents' memory recollection. This portion of the survey could be automated, similar to the Facebook data collection portion, by having respondents login to their frequent flyer accounts and retrieving the data directly from the various airlines. This

would eliminate memory recollection biases caused by the respondent and would be less time-consuming.

4.3 Contributions

This Master's thesis explores the creation of social weights matrices in a new manner. The contribution of this research is in determining methods of representing tie-strength using publically available friendship data collected from Facebook. Tie-strength is represented as a function of direct friendship, mutual friendship, or a combination of both. This research is a foundation for the consideration of social influences in travel behavior studies, discussed in the next section.

4.4 Future Research

Future research expanding on these contributions includes identifying different representations of tie-strength based on additional data and continued modeling of the social influence on travel behavior.

This study collected online social network data exclusively from Facebook.com to determine social tie-strength and examined only air travel for personal trips to U.S. and Canadian destinations. Tie-strength determination can be expanded by collecting additional data from Facebook.com, such as number of wall posts or photos together as discussed in Lewis et al. (2008), other online social networking sites (e.g. Twitter, Foursquare), or a combination of online social networks (Pappalardo et al., 2012). This information could be supplemented with more traditional in-person interviews in order to determine how accurately the online social network tie-strengths represent an individual's

offline social network tie-strengths. This research can also be expanded to include international air trips and business related air trips. Additionally, other transportation modes may be considered in future analysis. Online social network websites can be used in conjunction with traditional travel diaries to associate friendships with travel behavior as well.

These new datasets can be utilized to show the impact of an individual's social network on his travel behavior. Spatial models are currently used in transportation research to represent how an individual's behavior is similar to the behaviors of his neighbors, such as Paleti et al. (2012) which found that an individual's vehicle type choice was influenced by his neighbors (Paleti, Bhat, Pendyala, & Goulias, 2012). However, there has been little research as to whether this type of correlation is truly spatial or if the spatial correlation is actually a proxy for social correlation. Future research can explore whether an individual's travel behavior is influenced by his friends, some of whom may also be his neighbors. The use of online social network data can help distinguish between friends and neighbors.

This research can be further expanded to predict destination choice based on social networks. A dataset including social network data and air travel behavior, similar to the one used in this study, can be used in a discrete continuous model in order to predict the social influences on both the number of trips taken in a year and the distance traveled per trip. This two stage trip generation and distribution model builds on this research and the previous study done by Wall et al. (2014).

Online social networks provide a wealth of data that can be used in conjunction with travel diaries to explore social influences on travel. Having a better understanding

of how and why people travel can help transportation professionals anticipate future transportation needs.

APPENDIX A: CANDIDATE WEIGHT MATRICES

This appendix includes each of the candidate weights matrices as discussed in Section 2.3.2. Matrices are shown in the developed and row-standardized forms. Row and column labels indicate the unique user ID associated with each respondent. As observed, diagonals are zero values.

	147	148	150	151	152	153	155	159	161	162	163	165	166	167	169	171	172	173	176	179	182	184	185	187	188	189	190	192	195	196	198	203	204	205	211	212	216	223	224	225	228	231	232	234	235	236	237	239	242	244	245	246	249	250	251	253
147	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
155	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
162	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1
163	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0
166	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0
167	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
172	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
173	0	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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182	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0
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185	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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188	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	0	1	0	1	1	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0
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195	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	1	1	0	1	1	1	0	1	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0
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203	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
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205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
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224	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0
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232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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235	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	0	0	0	0	0	0
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239	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	0	1	0	0
242	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0
244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0
246	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
253	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3: Binary Matrix

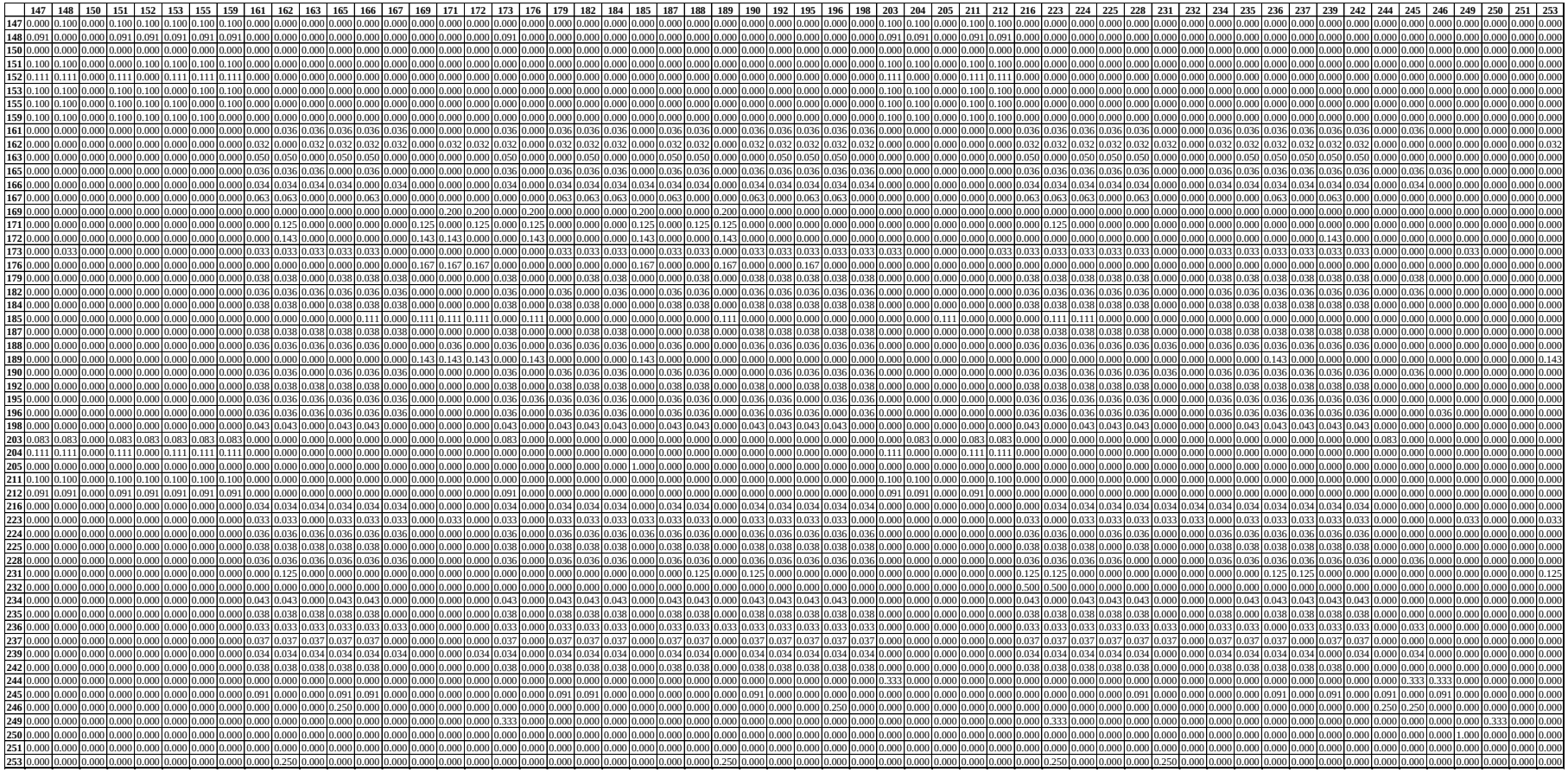
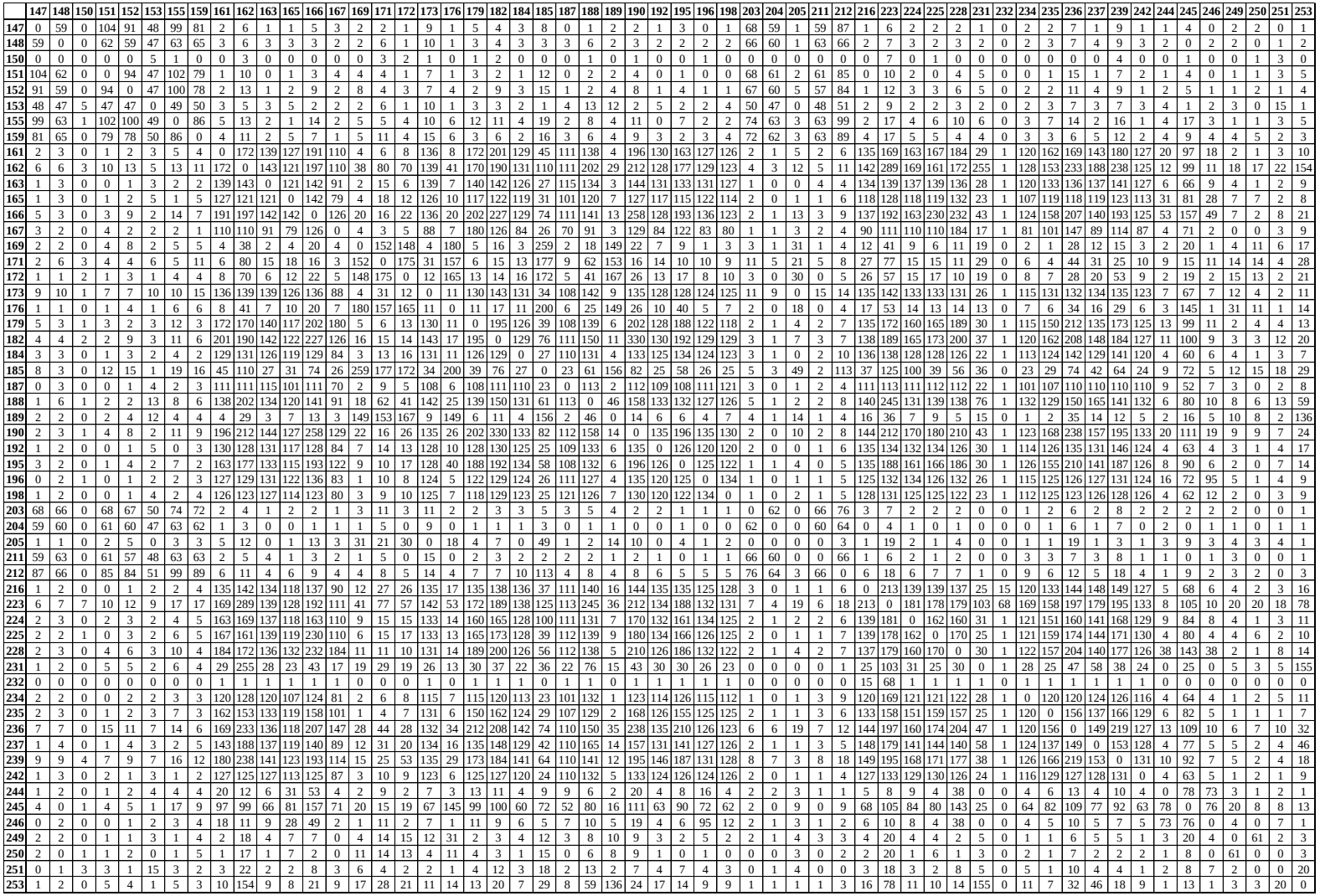


Figure 4: Binary Matrix – Row Standardized



	147	148	150	151	152	153	155	159	161	162	163	165	166	167	169	171	172	173	176	179	182	184	185	187	188	189	190	192	195	196	198	203	204	205	211	212	216	223	224	225	228	231	232	234	235	236	237	239	242	244	245	246	249	250	251	253
147	0	59	0	104	91	48	99	81	2	6	1	1	5	3	2	2	1	9	1	5	4	3	8	0	1	2	2	1	3	0	1	68	59	1	59	87	1	6	2	2	2	1	0	2	2	7	1	9	1	1	4	0	2	2	0	1
148	59	0	0	62	59	47	63	65	3	6	3	3	3	2	2	6	1	10	1	3	4	3	3	3	6	2	3	2	2	2	2	66	60	1	63	66	2	7	3	2	3	2	0	2	3	7	4	9	3	2	0	2	2	0	1	2
150	0	0	0	0	0	5	1	0	0	3	0	0	0	0	0	3	2	1	0	1	2	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	0	0	4	0	0	1	0	0	1	3	0
151	104	62	0	0	94	47	102	79	1	10	0	1	3	4	4	4	1	7	1	3	2	1	12	0	2	2	4	0	1	0	0	68	61	2	61	85	0	10	2	0	4	5	0	0	1	15	1	7	2	1	4	0	1	1	3	5
152	91	59	0	94	0	47	100	78	2	13	1	2	9	2	8	4	3	7	4	2	9	3	15	1	2	4	8	1	4	1	1	67	60	5	57	84	1	12	3	3	6	5	0	2	2	11	4	9	1	2	5	1	1	2	1	4
153	48	47	5	47	47	0	49	50	3	5	3	5	2	2	2	6	1	10	1	3	3	2	1	4	13	12	2	5	2	2	4	50	47	0	48	51	2	9	2	2	3	2	0	2	3	7	3	7	3	4	1	2	3	0	15	1
155	99	63	1	102	100	49	0	86	5	13	2	1	14	2	5	5	4	10	6	12	11	4	19	2	8	4	11	0	7	2	2	74	63	3	63	99	2	17	4	6	10	6	0	3	7	14	2	16	1	4	17	3	1	1	3	5
159	81	65	0	79	78	50	86	0	4	11	2	5	7	1	5	11	4	15	6	3	6	2	16	3	6	4	9	3	2	3	4	72	62	3	63	89	4	17	5	5	4	4	0	3	3	6	5	12	2	4	9	4	4	5	2	3
161	2	3	0	1	2	3	5	4	0	172	139	127	191	110	4	6	8	136	8	172	201	129	45	111	138	4	196	130	163	127	126	2	1	5	2	6	135	169	163	167	184	29	1	120	162	169	143	180	127	20	97	18	2	1	3	10
162	6	6	3	10	13	5	13	11	172	0	143	121	197	110	38	80	70	139	41	170	190	131	110	111	202	29	212	128	177	129	123	4	3	12	5	11	142	289	169	161	172	255	1	128	153	233	188	238	125	12	99	11	18	17	22	154
163	1	3	0	0	1	3	2	2	139	143	0	121	142	91	2	15	6	139	7	140	142	126	27	115	134	3	144	131	133	131	127	1	0	0	4	4	134	139	137	139	136	28	1	120	133	136	137	141	127	6	66	9	4	1	2	9
165	1	3	0	1	2	5	1	5	127	121	121	0	142	79	4	18	12	126	10	117	122	119	31	101	120	7	127	117	115	122	114	2	0	1	1	6	118	128	118	119	132	23	1	107	119	118	119	123	113	31	81	28	7	7	2	8
166	5	3	0	3	9	2	14	7	191	197	142	142	0	126	20	16	22	136	20	202	227	129	74	111	141	13	258	128	193	136	123	2	1	13	3	9	137	192	163	230	232	43	1	124	158	207	140	193	125	53	157	49	7	2	8	21
167	3	2	0	4	2	2	2	1	110	110	91	79	126	0	4	3	5	88	7	180	126	84	26	70	91	3	129	84	122	83	80	1	1	3	2	4	90	111	110	110	184	17	1	81	101	147	89	114	87	4	71	2	0	0	3	9
169	2	2	0	4	8	2	5	5	4	38	2	4	20	4	0	152	148	4	180	5	16	3	259	2	18	149	22	7	9	1	3	3	1	31	1	4	12	41	9	6	11	19	0	2	1	28	12	15	3	2	20	1	4	11	6	17
171	2	6	3	4	4	6	5	11	6	80	15	18	16	3	152	0	175	31	157	6	15	13	177	9	62	153	16	14	10	10	9	11	5	21	5	8	27	77	15	15	11	29	0	6	4	44	31	25	10	9	15	11	14	14	4	28
172	1	1	2	1	3	1	4	4	8	70	6	12	22	5	148	175	0	12	165	13	14	16	172	5	41	167	26	13	17	8	10	3	0	30	0	5	26	57	15	17	10	19	0	8	7	28	20	53	9	2	19	2	15	13	2	21
173	9	10	1	7	7	10	10	15	136	139	139	126	136	88	4	31	12	0	11	130	143	131	34	108	142	9	135	128	128	124	125	11	9	0	15	14	135	142	133	133	131	26	1	115	131	132	134	135	123	7	67	7	12	4	2	11
176	1	1	0	1	4	1	6	6	8	41	7	10	20	7	180	157	165	11	0	11	17	11	200	6	25	149	26	10	40	5	7	2	0	18	0	4	17	53	14	13	14	13	0	7	6	34	16	29	6	3	145	1	31	11	1	14
179	5	3	1	3	2	3	12	3	172	170	140	117	202	180	5	6	13	130	11	0	195	126	39	108	139	6	202	128	188	122	118	2	1	4	2	7	135	172	160	165	189	30	1	115	150	212	135	173	125	13	99	11	2	4	4	13
182	4	4	2	2	9	3	11	6	201	190	142	122	227	126	16	15	14	143	17	195	0	129	76	111	150	11	330	130	192	129	129	3	1	7	3	7	138	189	165	173	200	37	1	120	162	208	148	184	127	11	100	9	3	3	12	20
184	3	3	0	1	3	2	4	2	129	131	126	119	129	84	3	13	16	131	11	126	129	0	27	110	131	4	133	125	134	124	123	3	1	0	2	10	136	138	128	128	126	22	1	113	124	142	129	141	120	4	60	6	4	1	3	7
185	8	3	0	12	15	1	19	16	45	110	27	31	74	26	259	177	172	34	200	39	76	27	0	23	61	156	82	25	58	26	25	5	3	49	2	113	37	125	100	39	56	36	0	23	29	74	42	64	24	9	72	5	12	15	18	29
187	0	3	0	0	1	4	2	3	111	111	115	101	111	70	2	9	5	108	6	108	111	110	23	0	113	2	112	109	108	111	121	3	0	1	2	4	111	113	111	112	112	22	1	101	107	110	110	110	110	9	52	7	3	0	2	8
188	1	6	1	2	2	13	8	6	138	202	134	120	141	91	18	62	41	142	25	139	150	131	61	113	0	46	158	133	132	127	126	5	1	2	2	8	140	245	131	139	138	76	1	132	129	150	165	141	132	6	80	10	8	6	13	59
189	2	2	0	2	4	12	4	4	4	29	3	7	13	3	149	153	167	9	149	6	11	4	156	2	46	0	14	6	6	4	7	4	1	14	1	4	16	36	7	9	5	15	0	1	2	35	14	12	5	2	16	5	10	8	2	136
190	2	3	1	4	8	2	11	9	196	212	144	127	258	129	22	16	26	135	26	202	330	133	82	112	158	14	0	135	196	135	130	2	0	10	2	8	144	212	170	180	210	43	1	123	168	238	157	195	133	20	111	19	9	9	7	24
192	1	2	0	0	1	5	0	3	130	128	131	117	128	84	7	14	13	128	10	128	130	125	25	109	133	6	135	0	126	120	120	2	0	0	1	6	135	134	132	134	126	30	1	114	126	135	131	146	124	4	63	4	3	1	4	17
195	3	2	0	1	4	2	7	2	163	177	133	115	193	122	9	10	17	128	40	188	192	134	58	108	132	6	196	126	0	125	122	1	1	4	0	5	135	188	161	166	186	30	1	126	155	210	141	187	126	8	90	6	2	0	7	14
196	0	2	1	0	1	2	2	3	127	129	131	122	136	83	1	10	8	124	5	122	129	124	26	111	127	4	135	120	125	0	134	1	0	1	1	5	125	132	134	126	132	26	1	115	125	126	127	131	124	16	72	95	5	1	4	9
198	1	2	0	0	1	4	2	4	126	123	127	114	123	80	3	9	10	125	7	118	129	123	25	121	126	7	130	120	122	134	0	1	0	2	1	5	128	131	125	125	122	23	1	112	125	123	126	128	126	4	62	12	2	0	3	9
203	68	66	0	68	67	50	74	72	2	4	1	2	2	1	3	11	3	11	2	2	3	3	5	3	5	4	2	2	1	1	1	0	62	0	66	76	3	7	2	2	2	0	0	1	2	6	2	8	2	2	2	2	2	0	0	1
204	59	60	0	61	60	47	63	62	1	3	0	0	1	1	1	5	0	9	0	1	1	1	3	0	1	1	0	0	1	0	0	62	0	0	60	64	0	4	1	0	1	0	0	0	1	6	1	7	0	2	0	1	1	0	1	1
205	1	1	0	2	5	0	3	3	5	12	0	1	13	3	31	21	30	0	18	4	7	0	49	1	2	14	10	0	4	1	2	0	0	0	0	3	1	19	2	1	4	0	0	1	1	19	1	3	1	3	9	3	4	3	4	1
211	59	63	0	61	57	48	63	63	2	5	4	1	3	2	1	5	0	15	0	2	3	2	2	2	2	1	2	1	0	1	1	66	60	0	0	66	1	6	2	1	2	0	0	3	3	7	3	8	1	1	0	1	3	0	0	1
212	87	66	0	85	84	51	99	89	6	11	4	6	9	4	4	8	5	14	4	7	7	10	113	4	8	4	8	6	5	5	5	76	64	3	66	0	6	18	6	7	7	1	0	9	6	12	5	18	4	1	9	2	3	2	0	3
216	1	2	0	0	1	2	2	4	135	142	134	118	137	90	12	27	26	135	17	135	138	136	37	111	140	16	144	135	135	125	128	3	0	1	1	6	0	213	139	139	137	25	15	120	133	144	148	149	127	5	68	6	4	2	3	16
223	6	7	7	10	12	9	17	17	169	289	139	128	192	111	41	77	57	142	53	172	189	138	125	113	245	36	212	134	188	132	131	7	4	19	6	18	213	0	181	178	179	103	68	169	158	197	179	195	133	8	105	10	20	20	18	78
224	2	3	0	2	3	2	4	5	163	169	137	118	163	110	9	15	15	133	14	160	165	128	100	111	131	7	170	132	161	134	125	2	1	2	2	6	139	181	0	162	160	31	1	121	151	160	141	168	129	9	84	8	4	1	3	11
225	2	2	1	0	3	2	6	5	167	161	139	119	230	110	6	15	17	133	13	165	173	128	39	112	139	9	180	134	166	126	125	2	0	1	1	7	139	178	162	0	170	25	1	121	159	174	144	171	130	4	80	4	5	4	2	10
228	2	3	0	4	6	3	10	4	184	172	136	132	232	184	11	11	10	131	14	189	200	126	56	112	138	5	210	126	186	132	122	2	1	4	2	7	137	179	160	170	0	30	1	122	157	204	140	177	126	38	143	38	2	1	8	14
231	1	2	0	5	5	2	6	4	29	255	28	23	43	17	19	29	19	26	13	30	37	22	36	22	76	15	43	30	30	26	23	0	0	0	0	1	25	103	31	25	30	0	1	28	25	47	58	38	24	0	25	0	5	3	5	155
232	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	15	68	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
234	2	2	0	0	2	2	3	3	120	128	120	107	124	81	2	6	8	115	7	115	120	113	23	101	132	1	123	114	126	115	112	1	0	1	3	9	120	169	121	121	122	28	1	0	120	120	124	126	116	4	64	4	1	2	5	11
235	2	3	0	1	2	3	7	3	162	153	133	119	158	101	1	4	7	131	6	150	162	124	29	107	129	2	168	126	155	125	125	2	1	1	3	6	133	158	151	159	157	25	1	120	0	156	137	166	129	6	82	5	1	1	1	7
236	7	7	0	15	11	7	14	6	169	233	136	118	207	147	28	44	28	132	34	212	208	142	74	110	150	35	238	135	210	126	123	6	6	19	7	12	144	197	160	174	204	47	1	120	156	0	149	219	127	13	109	10	6	7	10	32
237	1	4	0	1	4	3	2	5	143	188	137	119	140	89	12	31	20	134	16	135	148	129	42	110	165	14	157	131	141	127	126	2	1	1	3	5	148	179	141	144	140	58	1	124	137	149	0	153	128	4	77	5	5	2	4	46
239	9	9	4	7	9	7	16	12	180	238	141	123	193	114	15	25	53	135	29	173	184	141	64	110	141	12	195	146	187	131	128	8	7	3	8	18	149	195	168	171	177	38	1	126	166	219	153	0	131	10	92	7	5	2	4	18
242	1	3	0	2	1	3	1	2	127	125	127	113	125	87	3	10	9	123	6	125	127	120	24	110	132	5	133	124	126	124	126	2	0	1	1	4	127	133	129	130	126	24	1	116	129	127	128	131	0	4	63	5	1	2	1	9
244	1	2	0	1	2	4	4	4	20	12	6	31	53	4	2	9	2	7	3	13	11	4	9	9	6	2	20	4	8	16	4	2	2	3	1	1	5	8	9	4	38	0	0	4	6	13	4	10	4	0	78	73	3	1	2	1
245	4	0	1	4	5	1	17	9	97	99	66	81	157	71	20	15	19	67	145	99	100	60	72	52	80	16	111	63	90	72	62	2	0	9	0	9	68	105	84	80	143	25	0	64	82	109	77	92	63	78	0	76	20	8	8	13
246	0	2	0	0	1	2	3	4	18	11	9	28	49	2	1	11	2	7	1	11	9	6	5	7	10	5	19	4	6	95	12	2	1	3	1	2	6	10	8	4	38	0	0	4	5	10	5	7	5	73	76	0	4	0	7	1
249	2	2	0	1	1	3	1	4	2	18	4	7	7	0	4	14	15	12	31	2	3	4	12	3	8	10	9	3	2	5	2	2	1	4	3	3	4	20	4	4	2	5	0	1	1	6	5	5	1	3	20	4	0	61	2	3
250	2	0	1	1	2	0	1	5	1	17	1	7	2	0	11	14	13	4	11	4	3	1	15	0	6	8	9	1	0	1	0	0	0	3	0	2	2	20	1	6	1	3	0	2	1	7	2	2	2	1	8	0	61	0	0	3
251	0	1	3	3	1	15	3	2	3	22	2	2	8	3	6	4	2	2	1	4	12	3	18	2	13	2	7	4	7	4	3	0	1	4	0	0	3	18	3	2	8	5	0	5	1	10	4	4	1	2	8	7	2	0	0	20
253	1	2	0	5	4	1	5	3	10	154	9	8	21	9	17	28	21	11	14	13	20	7	29	8	59	136	24	17	14	9	9	1	1	1	1	3	16	78	11	10	14	155	0	11	7	32	46	18	9	1	13	1	3	3	20	0

Figure 5: Number of Mutual Friends Matrix

	147	148	150	151	152	153	155	159	161	162	163	165	166	167	169	171	172	173	176	179	182	184	185	187	188	189	190	192
147	0.000	0.068	0.000	0.120	0.105	0.055	0.114	0.094	0.002	0.007	0.001	0.001	0.006	0.003	0.002	0.002	0.001	0.010	0.001	0.006	0.005	0.003	0.009	0.000	0.001	0.002	0.002	0.001
148	0.080	0.000	0.000	0.084	0.080	0.063	0.085	0.088	0.004	0.008	0.004	0.004	0.004	0.003	0.003	0.008	0.001	0.013	0.001	0.004	0.005	0.004	0.004	0.004	0.008	0.003	0.004	0.003
150	0.000	0.000	0.000	0.000	0.000	0.132	0.026	0.000	0.000	0.079	0.000	0.000	0.000	0.000	0.000	0.079	0.053	0.026	0.000	0.026	0.053	0.000	0.000	0.000	0.026	0.000	0.026	0.000
151	0.117	0.070	0.000	0.000	0.106	0.053	0.115	0.089	0.001	0.011	0.000	0.001	0.003	0.004	0.004	0.004	0.001	0.008	0.001	0.003	0.002	0.001	0.013	0.000	0.002	0.002	0.004	0.000
152	0.099	0.064	0.000	0.102	0.000	0.051	0.108	0.085	0.002	0.014	0.001	0.002	0.010	0.002	0.009	0.004	0.003	0.008	0.004	0.002	0.010	0.003	0.016	0.001	0.002	0.004	0.009	0.001
153	0.074	0.072	0.008	0.072	0.072	0.000	0.075	0.077	0.005	0.008	0.005	0.008	0.003	0.003	0.003	0.009	0.002	0.015	0.002	0.005	0.005	0.003	0.002	0.006	0.020	0.018	0.003	0.008
155	0.092	0.059	0.001	0.095	0.093	0.046	0.000	0.080	0.005	0.012	0.002	0.001	0.013	0.002	0.005	0.005	0.004	0.009	0.006	0.011	0.010	0.004	0.018	0.002	0.007	0.004	0.010	0.000
159	0.084	0.068	0.000	0.082	0.081	0.052	0.089	0.000	0.004	0.011	0.002	0.005	0.007	0.001	0.005	0.011	0.004	0.016	0.006	0.003	0.006	0.002	0.017	0.003	0.006	0.004	0.009	0.003
161	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.039	0.032	0.029	0.044	0.025	0.001	0.001	0.002	0.031	0.002	0.039	0.046	0.029	0.010	0.025	0.032	0.001	0.045	0.030
162	0.001	0.001	0.001	0.002	0.002	0.001	0.002	0.002	0.031	0.000	0.026	0.022	0.036	0.020	0.007	0.015	0.013	0.025	0.007	0.031	0.034	0.024	0.020	0.020	0.037	0.005	0.038	0.023
163	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.037	0.038	0.000	0.032	0.038	0.024	0.001	0.004	0.002	0.037	0.002	0.037	0.038	0.033	0.007	0.030	0.035	0.001	0.038	0.035
165	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.036	0.035	0.035	0.000	0.041	0.023	0.001	0.005	0.003	0.036	0.003	0.033	0.035	0.034	0.009	0.029	0.034	0.002	0.036	0.033
166	0.001	0.001	0.000	0.001	0.002	0.000	0.003	0.001	0.038	0.039	0.028	0.028	0.000	0.025	0.004	0.003	0.004	0.027	0.004	0.040	0.045	0.025	0.015	0.022	0.028	0.003	0.051	0.025
167	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.036	0.036	0.030	0.026	0.041	0.000	0.001	0.001	0.002	0.029	0.002	0.059	0.041	0.027	0.008	0.023	0.030	0.001	0.042	0.027
169	0.001	0.001	0.000	0.003	0.006	0.001	0.004	0.004	0.003	0.028	0.001	0.003	0.015	0.003	0.000	0.114	0.111	0.003	0.135	0.004	0.012	0.002	0.194	0.001	0.013	0.111	0.016	0.005
171	0.001	0.004	0.002	0.002	0.002	0.004	0.003	0.007	0.004	0.049	0.009	0.011	0.010	0.002	0.093	0.000	0.108	0.019	0.096	0.004	0.009	0.008	0.109	0.006	0.038	0.094	0.010	0.009
172	0.001	0.001	0.001	0.001	0.002	0.001	0.003	0.003	0.005	0.046	0.004	0.008	0.014	0.003	0.097	0.115	0.000	0.008	0.108	0.009	0.009	0.011	0.113	0.003	0.027	0.110	0.017	0.009
173	0.002	0.003	0.000	0.002	0.002	0.003	0.003	0.004	0.035	0.036	0.036	0.033	0.035	0.023	0.001	0.008	0.003	0.000	0.003	0.034	0.037	0.034	0.009	0.028	0.037	0.002	0.035	0.033
176	0.001	0.001	0.000	0.001	0.003	0.001	0.004	0.004	0.005	0.026	0.004	0.006	0.013	0.004	0.114	0.099	0.104	0.007	0.000	0.007	0.011	0.007	0.126	0.004	0.016	0.094	0.016	0.006
179	0.001	0.001	0.000	0.001	0.000	0.001	0.003	0.001	0.038	0.038	0.031	0.026	0.045	0.040	0.001	0.001	0.003	0.029	0.002	0.000	0.044	0.028	0.009	0.024	0.031	0.001	0.045	0.029
182	0.001	0.001	0.000	0.000	0.002	0.001	0.002	0.001	0.041	0.039	0.029	0.025	0.047	0.026	0.003	0.003	0.003	0.029	0.003	0.040	0.000	0.027	0.016	0.023	0.031	0.002	0.068	0.027
184	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.036	0.036	0.035	0.033	0.036	0.023	0.001	0.004	0.004	0.036	0.003	0.035	0.036	0.000	0.007	0.030	0.036	0.001	0.037	0.034
185	0.003	0.001	0.000	0.004	0.005	0.000	0.007	0.006	0.016	0.039	0.010	0.011	0.026	0.009	0.092	0.063	0.061	0.012	0.071	0.014	0.027	0.010	0.000	0.008	0.022	0.056	0.029	0.009
187	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.036	0.036	0.037	0.032	0.036	0.023	0.001	0.003	0.002	0.035	0.002	0.035	0.036	0.035	0.007	0.000	0.036	0.001	0.036	0.035
188	0.000	0.001	0.000	0.000	0.000	0.003	0.002	0.001	0.031	0.046	0.031	0.027	0.032	0.021	0.004	0.014	0.009	0.032	0.006	0.032	0.034	0.030	0.014	0.026	0.000	0.010	0.036	0.030
189	0.001	0.001	0.000	0.001	0.003	0.009	0.003	0.003	0.003	0.022	0.002	0.005	0.010	0.002	0.111	0.114	0.125	0.007	0.111	0.004	0.008	0.003	0.117	0.001	0.034	0.000	0.010	0.004
190	0.000	0.001	0.000	0.001	0.002	0.000	0.002	0.002	0.038	0.041	0.028	0.025	0.050	0.025	0.004	0.003	0.005	0.026	0.005	0.039	0.064	0.026	0.016	0.022	0.031	0.003	0.000	0.026
192	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.036	0.035	0.036	0.032	0.035	0.023	0.002	0.004	0.004	0.035	0.003	0.035	0.036	0.034	0.007	0.030	0.037	0.002	0.037	0.000
195	0.001	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.037	0.040	0.030	0.026	0.043	0.027	0.002	0.002	0.004	0.029	0.009	0.042	0.043	0.030	0.013	0.024	0.030	0.001	0.044	0.028
196	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.035	0.035	0.036	0.033	0.037	0.023	0.000	0.003	0.002	0.034	0.001	0.033	0.035	0.034	0.007	0.030	0.035	0.001	0.037	0.033
198	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.036	0.035	0.036	0.032	0.035	0.023	0.001	0.003	0.003	0.036	0.002	0.034	0.037	0.035	0.007	0.034	0.036	0.002	0.037	0.034
203	0.086	0.084	0.000	0.086	0.085	0.063	0.094	0.091	0.003	0.005	0.001	0.003	0.003	0.001	0.004	0.014	0.004	0.014	0.003	0.003	0.004	0.004	0.006	0.004	0.006	0.005	0.003	0.003
204	0.090	0.092	0.000	0.093	0.092	0.072	0.096	0.095	0.002	0.005	0.000	0.000	0.002	0.002	0.002	0.008	0.000	0.014	0.000	0.002	0.002	0.002	0.005	0.000	0.002	0.002	0.000	0.000
205	0.003	0.003	0.000	0.006	0.015	0.000	0.009	0.009	0.015	0.037	0.000	0.003	0.040	0.009	0.095	0.064	0.092	0.000	0.055	0.012	0.021	0.000	0.150	0.003	0.006	0.043	0.031	0.000
211	0.084	0.089	0.000	0.086	0.081	0.068	0.089	0.089	0.003	0.007	0.006	0.001	0.004	0.003	0.001	0.007	0.000	0.021	0.000	0.003	0.004	0.003	0.003	0.003	0.003	0.001	0.003	0.001
212	0.076	0.058	0.000	0.074	0.073	0.045	0.086	0.078	0.005	0.010	0.003	0.005	0.008	0.003	0.003	0.007	0.004	0.012	0.003	0.006	0.006	0.009	0.099	0.003	0.007	0.003	0.007	0.005
216	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.034	0.036	0.034	0.030	0.035	0.023	0.003	0.007	0.007	0.034	0.004	0.034	0.035	0.034	0.009	0.028	0.035	0.004	0.036	0.034
223	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.030	0.052	0.025	0.023	0.035	0.020	0.007	0.014	0.010	0.026	0.010	0.031	0.034	0.025	0.022	0.020	0.044	0.006	0.038	0.024
224	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.038	0.040	0.032	0.028	0.038	0.026	0.002	0.004	0.004	0.031	0.003	0.037	0.039	0.030	0.023	0.026	0.031	0.002	0.040	0.031
225	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.039	0.037	0.032	0.028	0.053	0.025	0.001	0.003	0.004	0.031	0.003	0.038	0.040	0.030	0.009	0.026	0.032	0.002	0.042	0.031
228	0.000	0.001	0.000	0.001	0.001	0.001	0.002	0.001	0.039	0.036	0.029	0.028	0.049	0.039	0.002	0.002	0.002	0.028	0.003	0.040	0.042	0.027	0.012	0.024	0.029	0.001	0.045	0.027
231	0.001	0.001	0.000	0.003	0.003	0.001	0.004	0.003	0.019	0.165	0.018	0.015	0.028	0.011	0.012	0.019	0.012	0.017	0.008	0.019	0.024	0.014	0.023	0.014	0.049	0.010	0.028	0.019
232	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.009	0.009	0.009	0.009	0.009	0.000	0.000	0.000	0.009	0.000	0.009	0.009	0.009	0.000	0.009	0.009	0.000	0.009	0.009
234	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.035	0.037	0.035	0.031	0.036	0.024	0.001	0.002	0.002	0.034	0.002	0.034	0.035	0.033	0.007	0.030	0.039	0.000	0.036	0.033
235	0.000	0.001	0.000	0.000	0.000	0.001	0.002	0.001	0.040	0.038	0.033	0.030	0.039	0.025	0.000	0.001	0.002	0.033	0.001	0.037	0.040	0.031	0.007	0.027	0.032	0.000	0.042	0.031
236	0.001	0.001	0.000	0.003	0.002	0.001	0.003	0.001	0.034	0.046	0.027	0.023	0.041	0.029	0.006	0.009	0.006	0.026	0.007	0.042	0.041	0.028	0.015	0.022	0.030	0.007	0.047	0.027
237	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.035	0.046	0.033	0.029	0.034	0.022	0.003	0.008	0.005	0.032	0.004	0.033	0.036	0.031	0.010	0.027	0.040	0.003	0.038	0.032
239	0.002	0.002	0.001	0.001	0.002	0.001	0.003	0.002	0.037	0.050	0.029	0.026	0.040	0.024	0.003	0.005	0.011	0.028	0.006	0.036	0.038	0.029	0.013	0.023	0.029	0.002	0.041	0.030
242	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.036	0.035	0.036	0.032	0.035	0.025	0.001	0.003	0.003	0.035	0.002	0.035	0.036	0.034	0.007	0.031	0.037	0.001	0.038	0.035
244	0.002	0.004	0.000	0.002	0.004	0.007	0.007	0.007	0.037	0.022	0.011	0.057	0.097	0.007	0.004	0.017	0.004	0.013	0.006	0.024	0.020	0.007	0.017	0.017	0.011	0.004	0.037	0.007
245	0.001	0.000	0.000	0.001	0.002	0.000	0.006	0.003	0.033	0.033	0.022	0.027	0.053	0.024	0.007	0.005	0.006	0.023	0.049	0.033	0.034	0.020	0.024	0.018	0.027	0.005	0.037	0.021
246	0.000	0.003	0.000	0.000	0.002	0.003	0.005	0.007	0.029	0.018	0.015	0.046	0.080	0.003	0.002	0.018	0.003	0.011	0.002	0.018	0.015	0.010	0.008	0.011	0.016	0.008	0.031	0.007
249	0.006	0.006	0.000	0.003	0.003	0.008	0.003	0.011	0.006	0.051	0.011	0.020	0.020	0.000	0.011	0.039	0.042	0.034	0.087	0.006	0.008	0.011	0.034	0.008	0.023	0.028	0.025	0.008
250	0.007	0.000	0.004	0.004	0.007	0.000	0.004	0.019	0.004	0.063	0.004	0.026	0.007	0.000	0.041	0.052	0.049	0.015	0.041	0.015	0.011	0.004	0.056	0.000	0.022	0.030	0.034	0.004
251	0.000	0.004	0.011	0.011	0.004	0.056	0.011	0.007	0.011	0.081	0.007	0.007	0.030	0.011	0.022	0.015	0.007	0.007	0.004	0.015	0.044	0.011	0.067	0.007	0.048	0.007	0.026	0.015
253	0.001	0.002	0.000	0.004	0.004	0.001	0.004	0.003	0.009	0.137	0.008	0.007	0.019	0.008	0.015	0.025	0.019	0.010	0.012	0.012	0.018	0.006	0.026	0.007	0.053	0.121	0.021	0.015

	195	196	198	203	204	205	211	212	216	223	224	225	228	231	232	234	235	236	237	239	242	244	245	246	249	250	251	253
147	0.003	0.000	0.001	0.079	0.068	0.001	0.068	0.101	0.001	0.007	0.002	0.002	0.002	0.001	0.000	0.002	0.002	0.008	0.001	0.010	0.001	0.001	0.005	0.000	0.002	0.002	0.000	0.001
148	0.003	0.003	0.003	0.089	0.081	0.001	0.085	0.089	0.003	0.009	0.004	0.003	0.004	0.003	0.000	0.003	0.004	0.009	0.005	0.012	0.004	0.003	0.000	0.003	0.003	0.000	0.001	0.003
150	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.184	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.105	0.000	0.000	0.026	0.000	0.000	0.026	0.079	0.000
151	0.001	0.000	0.000	0.076	0.069	0.002	0.069	0.096	0.000	0.011	0.002	0.000	0.004	0.006	0.000	0.000	0.001	0.017	0.001	0.008	0.002	0.001	0.004	0.000	0.001	0.001	0.003	0.006
152	0.004	0.001	0.001	0.073	0.065	0.005	0.062	0.091	0.001	0.013	0.003	0.003	0.007	0.005	0.000	0.002	0.002	0.012	0.004	0.010	0.001	0.002	0.005	0.001	0.001	0.002	0.001	0.004
153	0.003	0.003	0.006	0.077	0.072	0.000	0.074	0.078	0.003	0.014	0.003	0.003	0.005	0.003	0.000	0.003	0.005	0.011	0.005	0.011	0.005	0.006	0.002	0.003	0.005	0.000	0.023	0.002
155	0.007	0.002	0.002	0.069	0.059	0.003	0.059	0.092	0.002	0.016	0.004	0.006	0.009	0.006	0.000	0.003	0.007	0.013	0.002	0.015	0.001	0.004	0.016	0.003	0.001	0.001	0.003	0.005
159	0.002	0.003	0.004	0.075	0.065	0.003	0.066	0.093	0.004	0.018	0.005	0.005	0.004	0.004	0.000	0.003	0.003	0.006	0.005	0.012	0.002	0.004	0.009	0.004	0.004	0.005	0.002	0.003
161	0.037	0.029	0.029	0.000	0.000	0.001	0.000	0.001	0.031	0.039	0.037	0.038	0.042	0.007	0.000	0.027	0.037	0.039	0.033	0.041	0.029	0.005	0.022	0.004	0.000	0.000	0.001	0.002
162	0.032	0.023	0.022	0.001	0.001	0.002	0.001	0.002	0.026	0.052	0.031	0.029	0.031	0.046	0.000	0.023	0.028	0.042	0.034	0.043	0.023	0.002	0.018	0.002	0.003	0.003	0.004	0.028
163	0.035	0.035	0.034	0.000	0.000	0.000	0.001	0.001	0.035	0.037	0.036	0.037	0.036	0.007	0.000	0.032	0.035	0.036	0.036	0.037	0.034	0.002	0.017	0.002	0.001	0.000	0.001	0.002
165	0.033	0.035	0.033	0.001	0.000	0.000	0.000	0.002	0.034	0.037	0.034	0.034	0.038	0.007	0.000	0.031	0.034	0.034	0.034	0.035	0.032	0.009	0.023	0.008	0.002	0.002	0.001	0.002
166	0.038	0.027	0.024	0.000	0.000	0.003	0.001	0.002	0.027	0.038	0.032	0.045	0.046	0.008	0.000	0.025	0.031	0.041	0.028	0.038	0.025	0.010	0.031	0.010	0.001	0.000	0.002	0.004
167	0.040	0.027	0.026	0.000	0.000	0.001	0.001	0.001	0.029	0.036	0.036	0.036	0.060	0.006	0.000	0.026	0.033	0.048	0.029	0.037	0.028	0.001	0.023	0.001	0.000	0.000	0.001	0.003
169	0.007	0.001	0.002	0.002	0.001	0.023	0.001	0.003	0.009	0.031	0.007	0.004	0.008	0.014	0.000	0.001	0.001	0.021	0.009	0.011	0.002	0.001	0.015	0.001	0.003	0.008	0.004	0.013
171	0.006	0.006	0.006	0.007	0.003	0.013	0.003	0.005	0.017	0.047	0.009	0.009	0.007	0.018	0.000	0.004	0.002	0.027	0.019	0.015	0.006	0.006	0.009	0.007	0.009	0.009	0.002	0.017
172	0.011	0.005	0.007	0.002	0.000	0.020	0.000	0.003	0.017	0.037	0.010	0.011	0.007	0.012	0.000	0.005	0.005	0.018	0.013	0.035	0.006	0.001	0.012	0.001	0.010	0.009	0.001	0.014
173	0.033	0.032	0.032	0.003	0.002	0.000	0.004	0.004	0.035	0.037	0.034	0.034	0.034	0.007	0.000	0.030	0.034	0.034	0.035	0.035	0.032	0.002	0.017	0.002	0.003	0.001	0.001	0.003
176	0.025	0.003	0.004	0.001	0.000	0.011	0.000	0.003	0.011	0.033	0.009	0.008	0.009	0.008	0.000	0.004	0.004	0.021	0.010	0.018	0.004	0.002	0.091	0.001	0.020	0.007	0.001	0.009
179	0.042	0.027	0.026	0.000	0.000	0.001	0.000	0.002	0.030	0.038	0.036	0.037	0.042	0.007	0.000	0.026	0.034	0.047	0.030	0.039	0.028	0.003	0.022	0.002	0.000	0.001	0.001	0.003
182	0.039	0.027	0.027	0.001	0.000	0.001	0.001	0.001	0.028	0.039	0.034	0.036	0.041	0.008	0.000	0.025	0.033	0.043	0.030	0.038	0.026	0.002	0.021	0.002	0.001	0.001	0.002	0.004
184	0.037	0.034	0.034	0.001	0.000	0.000	0.001	0.003	0.038	0.038	0.035	0.035	0.035	0.006	0.000	0.031	0.034	0.039	0.036	0.039	0.033	0.001	0.017	0.002	0.001	0.000	0.001	0.002
185	0.021	0.009	0.009	0.002	0.001	0.017	0.001	0.040	0.013	0.045	0.036	0.014	0.020	0.013	0.000	0.008	0.010	0.026	0.015	0.023	0.009	0.003	0.026	0.002	0.004	0.005	0.006	0.010
187	0.035	0.036	0.039	0.001	0.000	0.000	0.001	0.001	0.036	0.036	0.036	0.036	0.036	0.007	0.000	0.032	0.034	0.035	0.035	0.035	0.035	0.003	0.017	0.002	0.001	0.000	0.001	0.003
188	0.030	0.029	0.029	0.001	0.000	0.000	0.000	0.002	0.032	0.056	0.030	0.032	0.031	0.017	0.000	0.030	0.029	0.034	0.038	0.032	0.030	0.001	0.018	0.002	0.002	0.001	0.003	0.013
189	0.004	0.003	0.005	0.003	0.001	0.010	0.001	0.003	0.012	0.027	0.005	0.007	0.004	0.011	0.000	0.001	0.001	0.026	0.010	0.009	0.004	0.001	0.012	0.004	0.007	0.006	0.001	0.102
190	0.038	0.026	0.025	0.000	0.000	0.002	0.000	0.002	0.028	0.041	0.033	0.035	0.041	0.008	0.000	0.024	0.033	0.046	0.030	0.038	0.026	0.004	0.022	0.004	0.002	0.002	0.001	0.005
192	0.035	0.033	0.033	0.001	0.000	0.000	0.000	0.002	0.037	0.037	0.036	0.037	0.035	0.008	0.000	0.031	0.035	0.037	0.036	0.040	0.034	0.001	0.017	0.001	0.001	0.000	0.001	0.005
195	0.000	0.028	0.027	0.000	0.000	0.001	0.000	0.001	0.030	0.042	0.036	0.037	0.042	0.007	0.000	0.028	0.035	0.047	0.032	0.042	0.028	0.002	0.020	0.001	0.000	0.000	0.002	0.003
196	0.034	0.000	0.036	0.000	0.000	0.000	0.000	0.001	0.034	0.036	0.036	0.034	0.036	0.007	0.000	0.031	0.034	0.034	0.035	0.036	0.034	0.004	0.020	0.026	0.001	0.000	0.001	0.002
198	0.035	0.038	0.000	0.000	0.000	0.001	0.000	0.001	0.036	0.037	0.036	0.036	0.035	0.007	0.000	0.032	0.036	0.035	0.036	0.036	0.036	0.001	0.018	0.003	0.001	0.000	0.001	0.003
203	0.001	0.001	0.001	0.000	0.079	0.000	0.084	0.096	0.004	0.009	0.003	0.003	0.003	0.000	0.000	0.001	0.003	0.008	0.003	0.010	0.003	0.003	0.003	0.003	0.003	0.000	0.000	0.001
204	0.002	0.000	0.000	0.095	0.000	0.000	0.092	0.098	0.000	0.006	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.009	0.002	0.011	0.000	0.003	0.000	0.002	0.002	0.000	0.002	0.002
205	0.012	0.003	0.006	0.000	0.000	0.000	0.000	0.009	0.003	0.058	0.006	0.003	0.012	0.000	0.000	0.003	0.003	0.058	0.003	0.009	0.003	0.009	0.028	0.009	0.012	0.009	0.012	0.003
211	0.000	0.001	0.001	0.093	0.085	0.000	0.000	0.093	0.001	0.008	0.003	0.001	0.003	0.000	0.000	0.004	0.004	0.010	0.004	0.011	0.001	0.001	0.000	0.001	0.004	0.000	0.000	0.001
212	0.004	0.004	0.004	0.066	0.056	0.003	0.058	0.000	0.005	0.016	0.005	0.006	0.006	0.001	0.000	0.008	0.005	0.010	0.004	0.016	0.003	0.001	0.008	0.002	0.003	0.002	0.000	0.003
216	0.034	0.031	0.032	0.001	0.000	0.000	0.000	0.002	0.000	0.054	0.035	0.035	0.035	0.006	0.004	0.030	0.034	0.036	0.037	0.038	0.032	0.001	0.017	0.002	0.001	0.001	0.001	0.004
223	0.034	0.024	0.024	0.001	0.001	0.003	0.001	0.003	0.038	0.000	0.033	0.032	0.032	0.019	0.012	0.030	0.028	0.035	0.032	0.035	0.024	0.001	0.019	0.002	0.004	0.004	0.003	0.014
224	0.038	0.031	0.029	0.000	0.000	0.000	0.000	0.001	0.033	0.042	0.000	0.038	0.037	0.007	0.000	0.028	0.035	0.037	0.033	0.039	0.030	0.002	0.020	0.002	0.001	0.000	0.001	0.003
225	0.038	0.029	0.029	0.000	0.000	0.000	0.000	0.002	0.032	0.041	0.037	0.000	0.039	0.006	0.000	0.028	0.037	0.040	0.033	0.040	0.030	0.001	0.019	0.001	0.001	0.001	0.000	0.002
228	0.039	0.028	0.026	0.000	0.000	0.001	0.000	0.001	0.029	0.038	0.034	0.036	0.000	0.006	0.000	0.026	0.033	0.043	0.030	0.038	0.027	0.008	0.030	0.008	0.000	0.000	0.002	0.003
231	0.019	0.017	0.015	0.000	0.000	0.000	0.000	0.001	0.016	0.067	0.020	0.016	0.019	0.000	0.001	0.018	0.016	0.030	0.038	0.025	0.016	0.000	0.016	0.000	0.003	0.002	0.003	0.100
232	0.009	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.136	0.618	0.009	0.009	0.009	0.009	0.000	0.009	0.009	0.009	0.009	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000
234	0.037	0.034	0.033	0.000	0.000	0.000	0.001	0.003	0.035	0.049	0.035	0.035	0.036	0.008	0.000	0.000	0.035	0.035	0.036	0.037	0.034	0.001	0.019	0.001	0.000	0.001	0.001	0.003
235	0.039	0.031	0.031	0.000	0.000	0.000	0.001	0.001	0.033	0.039	0.038	0.040	0.039	0.006	0.000	0.030	0.000	0.039	0.034	0.041	0.032	0.001	0.020	0.001	0.000	0.000	0.000	0.002
236	0.042	0.025	0.024	0.001	0.001	0.004	0.001	0.002	0.029	0.039	0.032	0.035	0.040	0.009	0.000	0.024	0.031	0.000	0.030	0.043	0.025	0.003	0.022	0.002	0.001	0.001	0.002	0.006
237	0.034	0.031	0.031	0.000	0.000	0.000	0.001	0.001	0.036	0.043	0.034	0.035	0.034	0.014	0.000	0.030	0.033	0.036	0.000	0.037	0.031	0.001	0.019	0.001	0.001	0.000	0.001	0.011
239	0.039	0.027	0.027	0.002	0.001	0.001	0.002	0.004	0.031	0.041	0.035	0.036	0.037	0.008	0.000	0.026	0.035	0.046	0.032	0.000	0.027	0.002	0.019	0.001	0.001	0.000	0.001	0.004
242	0.036	0.035	0.036	0.001	0.000	0.000	0.000	0.001	0.036	0.038	0.036	0.037	0.036	0.007	0.000	0.033	0.036	0.036	0.036	0.037	0.000	0.001	0.018	0.001	0.000	0.001	0.000	0.003
244	0.015	0.029	0.007	0.004	0.004	0.006	0.002	0.002	0.009	0.015	0.017	0.007	0.070	0.000	0.000	0.007	0.011	0.024	0.007	0.018	0.007	0.000	0.143	0.134	0.006	0.002	0.004	0.002
245	0.030	0.024	0.021	0.001	0.000	0.003	0.000	0.003	0.023	0.035	0.028	0.027	0.048	0.008	0.000	0.022	0.028	0.037	0.026	0.031	0.021	0.026	0.000	0.026	0.007	0.003	0.003	0.004
246	0.010	0.155	0.020	0.003	0.002	0.005	0.002	0.003	0.010	0.016	0.013	0.007	0.062	0.000	0.000	0.007	0.008	0.016	0.008	0.011	0.008	0.119	0.124	0.000	0.007	0.000	0.011	0.002
249	0.006	0.014	0.006	0.006	0.003	0.011	0.008	0.008	0.011	0.056	0.011	0.011	0.006	0.014	0.000	0.003	0.003	0.017	0.014	0.014	0.003	0.008	0.056	0.011	0.000	0.172	0.006	0.008
250	0.000	0.004	0.000	0.000	0.000	0.011	0.000	0.007	0.007	0.075	0.004	0.022	0.004	0.011	0.000	0.007	0.004	0.026	0.007	0.007	0.007	0.004	0.030	0.000	0.228	0.000	0.000	0.011
251	0.026	0.015	0.011	0.000	0.004	0.015	0.000	0.000	0.011	0.067	0.011	0.007	0.030	0.019	0.000	0.019	0.004	0.037	0.015	0.015	0.004	0.007	0.030	0.026	0.007	0.000	0.000	0.074
253	0.012	0.008	0.008	0.001	0.001	0.001	0.001	0.003	0.014	0.069	0.010	0.009	0.012	0.138	0.000	0.010	0.006	0.028	0.041	0.016	0.008	0.001	0.012	0.001	0.003	0.003	0.018	0.000

Figure 6: Number of Mutual Friends Matrix – Row Standardized

	147	148	150	151	152	153	155	159	161	162	163	165	166	167	169	171	172	173	176
147	0.000	0.084	0.000	0.157	0.109	0.072	0.131	0.064	0.002	0.005	0.001	0.001	0.004	0.004	0.002	0.001	0.001	0.011	0.001
148	0.084	0.000	0.000	0.086	0.066	0.065	0.077	0.049	0.003	0.005	0.003	0.003	0.002	0.003	0.001	0.004	0.001	0.011	0.001
150	0.000	0.000	0.000	0.000	0.000	0.008	0.001	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.001	0.000
151	0.157	0.086	0.000	0.000	0.111	0.069	0.133	0.062	0.001	0.009	0.000	0.001	0.002	0.006	0.003	0.003	0.001	0.008	0.001
152	0.109	0.066	0.000	0.111	0.000	0.055	0.106	0.054	0.002	0.010	0.001	0.002	0.006	0.002	0.005	0.002	0.002	0.007	0.003
153	0.072	0.065	0.008	0.069	0.055	0.000	0.063	0.039	0.003	0.004	0.003	0.006	0.002	0.003	0.002	0.004	0.001	0.012	0.001
155	0.131	0.077	0.001	0.133	0.106	0.063	0.000	0.063	0.004	0.011	0.002	0.001	0.010	0.003	0.004	0.003	0.003	0.010	0.004
159	0.064	0.049	0.000	0.062	0.054	0.039	0.063	0.000	0.002	0.006	0.001	0.003	0.004	0.001	0.003	0.005	0.002	0.010	0.003
161	0.002	0.003	0.000	0.001	0.002	0.003	0.004	0.002	0.000	0.111	0.107	0.099	0.112	0.099	0.002	0.003	0.005	0.107	0.005
162	0.005	0.005	0.003	0.009	0.010	0.004	0.011	0.006	0.111	0.000	0.106	0.090	0.112	0.095	0.022	0.041	0.040	0.105	0.024
163	0.001	0.003	0.000	0.000	0.001	0.003	0.002	0.001	0.107	0.106	0.000	0.112	0.094	0.100	0.001	0.009	0.004	0.130	0.005
165	0.001	0.003	0.000	0.001	0.002	0.006	0.001	0.003	0.099	0.090	0.112	0.000	0.095	0.088	0.003	0.011	0.008	0.119	0.007
166	0.004	0.002	0.000	0.002	0.006	0.002	0.010	0.004	0.112	0.112	0.094	0.095	0.000	0.095	0.010	0.008	0.012	0.092	0.011
167	0.004	0.003	0.000	0.006	0.002	0.003	0.003	0.001	0.099	0.095	0.100	0.088	0.095	0.000	0.003	0.002	0.004	0.100	0.005
169	0.002	0.001	0.000	0.003	0.005	0.002	0.004	0.003	0.002	0.022	0.001	0.003	0.010	0.003	0.000	0.072	0.078	0.003	0.095
171	0.001	0.004	0.002	0.003	0.002	0.004	0.003	0.005	0.003	0.041	0.009	0.011	0.008	0.002	0.072	0.000	0.083	0.018	0.075
172	0.001	0.001	0.002	0.001	0.002	0.001	0.003	0.002	0.005	0.040	0.004	0.008	0.012	0.004	0.078	0.083	0.000	0.008	0.088
173	0.011	0.011	0.001	0.008	0.007	0.012	0.010	0.010	0.107	0.105	0.130	0.119	0.092	0.100	0.003	0.018	0.008	0.000	0.008
176	0.001	0.001	0.000	0.001	0.003	0.001	0.004	0.003	0.005	0.024	0.005	0.007	0.011	0.005	0.095	0.075	0.088	0.008	0.000
179	0.004	0.002	0.001	0.002	0.001	0.002	0.008	0.002	0.099	0.095	0.091	0.076	0.103	0.133	0.003	0.003	0.007	0.086	0.006
182	0.003	0.003	0.002	0.002	0.006	0.002	0.008	0.003	0.123	0.113	0.100	0.086	0.123	0.102	0.009	0.007	0.008	0.102	0.009
184	0.004	0.003	0.000	0.001	0.003	0.002	0.004	0.001	0.102	0.099	0.118	0.113	0.087	0.096	0.002	0.008	0.011	0.126	0.008
185	0.004	0.001	0.000	0.006	0.007	0.000	0.009	0.006	0.019	0.044	0.012	0.014	0.028	0.013	0.098	0.063	0.066	0.015	0.077
187	0.000	0.004	0.000	0.000	0.001	0.005	0.002	0.002	0.097	0.093	0.122	0.108	0.082	0.092	0.001	0.006	0.004	0.117	0.005
188	0.001	0.004	0.001	0.001	0.001	0.009	0.005	0.003	0.075	0.107	0.082	0.074	0.069	0.063	0.009	0.028	0.020	0.088	0.012
189	0.002	0.002	0.000	0.002	0.003	0.010	0.003	0.002	0.002	0.017	0.002	0.005	0.007	0.002	0.081	0.075	0.092	0.006	0.082
190	0.001	0.002	0.001	0.003	0.005	0.001	0.007	0.004	0.102	0.108	0.084	0.074	0.121	0.084	0.010	0.007	0.012	0.080	0.012
192	0.001	0.002	0.000	0.000	0.001	0.006	0.000	0.002	0.107	0.101	0.129	0.117	0.089	0.101	0.005	0.009	0.009	0.129	0.007
195	0.003	0.002	0.000	0.001	0.003	0.002	0.006	0.001	0.111	0.117	0.105	0.092	0.115	0.114	0.005	0.005	0.010	0.104	0.024
196	0.000	0.002	0.001	0.000	0.001	0.002	0.002	0.002	0.096	0.094	0.117	0.110	0.089	0.089	0.001	0.006	0.005	0.114	0.003
198	0.001	0.002	0.000	0.000	0.001	0.005	0.002	0.003	0.107	0.100	0.130	0.118	0.088	0.101	0.002	0.006	0.007	0.131	0.005
203	0.124	0.109	0.000	0.121	0.091	0.088	0.113	0.062	0.002	0.004	0.001	0.003	0.002	0.002	0.003	0.008	0.003	0.015	0.002
204	0.118	0.108	0.000	0.120	0.088	0.091	0.104	0.056	0.001	0.003	0.000	0.000	0.001	0.002	0.001	0.004	0.000	0.013	0.000
205	0.001	0.001	0.000	0.002	0.005	0.000	0.003	0.002	0.004	0.009	0.000	0.001	0.009	0.004	0.021	0.013	0.021	0.000	0.013
211	0.054	0.054	0.000	0.055	0.044	0.043	0.052	0.037	0.001	0.003	0.003	0.001	0.002	0.002	0.001	0.003	0.000	0.012	0.000
212	0.091	0.066	0.000	0.088	0.074	0.053	0.093	0.057	0.004	0.008	0.003	0.005	0.006	0.004	0.003	0.004	0.003	0.012	0.003
216	0.001	0.003	0.000	0.000	0.001	0.003	0.003	0.003	0.123	0.123	0.149	0.133	0.104	0.126	0.009	0.018	0.020	0.155	0.013
223	0.004	0.005	0.005	0.007	0.008	0.006	0.011	0.009	0.093	0.155	0.087	0.080	0.095	0.078	0.020	0.035	0.028	0.090	0.027
224	0.003	0.004	0.000	0.003	0.003	0.003	0.005	0.004	0.140	0.139	0.143	0.124	0.119	0.142	0.007	0.010	0.011	0.142	0.010
225	0.002	0.002	0.001	0.000	0.002	0.002	0.005	0.003	0.114	0.106	0.110	0.095	0.137	0.102	0.004	0.008	0.010	0.108	0.008
228	0.002	0.003	0.000	0.004	0.005	0.003	0.009	0.002	0.125	0.113	0.107	0.105	0.138	0.170	0.007	0.006	0.006	0.105	0.008
231	0.001	0.003	0.000	0.007	0.006	0.003	0.008	0.003	0.026	0.220	0.031	0.026	0.033	0.024	0.014	0.019	0.015	0.030	0.010
232	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.000
234	0.003	0.003	0.000	0.000	0.002	0.003	0.004	0.002	0.112	0.114	0.138	0.125	0.096	0.119	0.002	0.004	0.006	0.136	0.006
235	0.002	0.003	0.000	0.001	0.002	0.003	0.006	0.002	0.109	0.100	0.104	0.094	0.093	0.092	0.001	0.002	0.004	0.104	0.004
236	0.005	0.005	0.000	0.010	0.007	0.005	0.009	0.003	0.090	0.120	0.081	0.071	0.099	0.098	0.013	0.019	0.013	0.080	0.016
237	0.001	0.003	0.000	0.001	0.003	0.002	0.001	0.002	0.078	0.100	0.084	0.074	0.068	0.062	0.006	0.014	0.010	0.083	0.008
239	0.007	0.007	0.003	0.005	0.006	0.005	0.011	0.006	0.104	0.133	0.092	0.081	0.099	0.085	0.008	0.012	0.028	0.090	0.015
242	0.001	0.003	0.000	0.002	0.001	0.004	0.001	0.001	0.103	0.097	0.123	0.111	0.086	0.103	0.002	0.006	0.006	0.122	0.004
244	0.001	0.002	0.000	0.001	0.002	0.005	0.005	0.003	0.017	0.010	0.006	0.031	0.037	0.005	0.001	0.006	0.001	0.007	0.002
245	0.003	0.000	0.001	0.002	0.003	0.001	0.010	0.004	0.048	0.048	0.036	0.045	0.070	0.043	0.009	0.006	0.009	0.037	0.066
246	0.000	0.002	0.000	0.000	0.001	0.002	0.003	0.003	0.014	0.008	0.008	0.026	0.032	0.002	0.001	0.006	0.001	0.007	0.001
249	0.002	0.002	0.000	0.001	0.001	0.002	0.001	0.002	0.001	0.011	0.003	0.005	0.004	0.000	0.002	0.007	0.008	0.009	0.017
250	0.002	0.000	0.001	0.001	0.002	0.000	0.001	0.003	0.001	0.013	0.001	0.007	0.001	0.000	0.007	0.008	0.009	0.004	0.008
251	0.000	0.001	0.005	0.004	0.001	0.022	0.004	0.002	0.003	0.019	0.002	0.002	0.006	0.004	0.005	0.003	0.002	0.002	0.001
253	0.001	0.002	0.000	0.005	0.003	0.001	0.004	0.002	0.007	0.101	0.007	0.006	0.012	0.008	0.010	0.015	0.013	0.009	0.008

	179	182	184	185	187	188	189	190	192	195	196	198	203	204	205	211	212	216	223
147	0.004	0.003	0.004	0.004	0.000	0.001	0.002	0.001	0.001	0.003	0.000	0.001	0.124	0.118	0.001	0.054	0.091	0.001	0.004
148	0.002	0.003	0.003	0.001	0.004	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.109	0.108	0.001	0.054	0.066	0.003	0.005
150	0.001	0.002	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
151	0.002	0.002	0.001	0.006	0.000	0.001	0.002	0.003	0.000	0.001	0.000	0.000	0.121	0.120	0.002	0.055	0.088	0.000	0.007
152	0.001	0.006	0.003	0.007	0.001	0.001	0.003	0.005	0.001	0.003	0.001	0.001	0.091	0.088	0.005	0.044	0.074	0.001	0.008
153	0.002	0.002	0.002	0.000	0.005	0.009	0.010	0.001	0.006	0.002	0.002	0.005	0.088	0.091	0.000	0.043	0.053	0.003	0.006
155	0.008	0.008	0.004	0.009	0.002	0.005	0.003	0.007	0.000	0.006	0.002	0.002	0.113	0.104	0.003	0.052	0.093	0.003	0.011
159	0.002	0.003	0.001	0.006	0.002	0.003	0.002	0.004	0.002	0.001	0.002	0.003	0.062	0.056	0.002	0.037	0.057	0.003	0.009
161	0.099	0.123	0.102	0.019	0.097	0.075	0.002	0.102	0.107	0.111	0.096	0.107	0.002	0.001	0.004	0.001	0.004	0.123	0.093
162	0.095	0.113	0.099	0.044	0.093	0.107	0.017	0.108	0.101	0.117	0.094	0.100	0.004	0.003	0.009	0.003	0.008	0.123	0.155
163	0.091	0.100	0.118	0.012	0.122	0.082	0.002	0.084	0.129	0.105	0.117	0.130	0.001	0.000	0.000	0.003	0.003	0.149	0.087
165	0.076	0.086	0.113	0.014	0.108	0.074	0.005	0.074	0.117	0.092	0.110	0.118	0.003	0.000	0.001	0.001	0.005	0.133	0.080
166	0.103	0.123	0.087	0.028	0.082	0.069	0.007	0.121	0.089	0.115	0.089	0.088	0.002	0.001	0.009	0.002	0.006	0.104	0.095
167	0.133	0.102	0.096	0.013	0.092	0.063	0.002	0.084	0.101	0.114	0.089	0.101	0.002	0.002	0.004	0.002	0.004	0.126	0.078
169	0.003	0.009	0.002	0.098	0.001	0.009	0.081	0.010	0.005	0.005	0.001	0.002	0.003	0.001	0.021	0.001	0.003	0.009	0.020
171	0.003	0.007	0.008	0.063	0.006	0.028	0.075	0.007	0.009	0.005	0.006	0.006	0.008	0.004	0.013	0.003	0.004	0.018	0.035
172	0.007	0.008	0.011	0.066	0.004	0.020	0.092	0.012	0.009	0.010	0.005	0.007	0.003	0.000	0.021	0.000	0.003	0.020	0.028
173	0.086	0.102	0.126	0.015	0.117	0.088	0.006	0.080	0.129	0.104	0.114	0.131	0.015	0.013	0.000	0.012	0.012	0.155	0.090
176	0.006	0.009	0.008	0.077	0.005	0.012	0.082	0.012	0.007	0.024	0.003	0.005	0.002	0.000	0.013	0.000	0.003	0.013	0.027
179	0.000	0.104	0.083	0.015	0.078	0.067	0.003	0.093	0.087	0.110	0.078	0.083	0.002	0.001	0.003	0.001	0.004	0.100	0.084
182	0.104	0.000	0.092	0.030	0.087	0.076	0.006	0.161	0.097	0.121	0.089	0.099	0.003	0.001	0.005	0.002	0.005	0.112	0.098
184	0.083	0.092	0.000	0.012	0.120	0.081	0.003	0.079	0.127	0.109	0.114	0.130	0.004	0.001	0.000	0.002	0.009	0.157	0.088
185	0.015	0.030	0.012	0.000	0.011	0.022	0.061	0.029	0.012	0.024	0.012	0.012	0.003	0.002	0.023	0.001	0.049	0.018	0.046
187	0.078	0.087	0.120	0.011	0.000	0.076	0.002	0.071	0.126	0.097	0.115	0.146	0.005	0.000	0.001	0.002	0.004	0.148	0.078
188	0.067	0.076	0.081	0.022	0.076	0.000	0.023	0.070	0.085	0.073	0.076	0.083	0.004	0.001	0.001	0.001	0.005	0.097	0.114
189	0.003	0.006	0.003	0.061	0.002	0.023	0.000	0.007	0.004	0.004	0.003	0.005	0.004	0.001	0.010	0.001	0.003	0.013	0.019
190	0.093	0.161	0.079	0.029	0.071	0.070	0.007	0.000	0.082	0.104	0.078	0.081	0.001	0.000	0.006	0.001	0.004	0.095	0.095
192	0.087	0.097	0.127	0.012	0.126	0.085	0.004	0.082	0.000	0.107	0.116	0.134	0.003	0.000	0.000	0.001	0.005	0.165	0.088
195	0.110	0.121	0.109	0.024	0.097	0.073	0.004	0.104	0.107	0.000	0.097	0.107	0.001	0.001	0.003	0.000	0.004	0.127	0.106
196	0.078	0.089	0.114	0.012	0.115	0.076	0.003	0.078	0.116	0.097	0.000	0.134	0.001	0.000	0.001	0.001	0.004	0.136	0.081
198	0.083	0.099	0.130	0.012	0.146	0.083	0.005	0.081	0.134	0.107	0.134	0.000	0.002	0.000	0.002	0.001	0.005	0.164	0.088
203	0.002	0.003	0.004	0.003	0.005	0.004	0.004	0.001	0.003	0.001	0.001	0.002	0.000	0.156	0.000	0.066	0.089	0.005	0.005
204	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.156	0.000	0.000	0.063	0.080	0.000	0.003
205	0.003	0.005	0.000	0.023	0.001	0.001	0.010	0.006	0.000	0.003	0.001	0.002	0.000	0.000	0.000	0.000	0.003	0.001	0.012
211	0.001	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.066	0.063	0.000	0.000	0.047	0.001	0.003
212	0.004	0.005	0.009	0.049	0.004	0.005	0.003	0.004	0.005	0.004	0.004	0.005	0.089	0.080	0.003	0.047	0.000	0.006	0.011
216	0.100	0.112	0.157	0.018	0.148	0.097	0.013	0.095	0.165	0.127	0.136	0.164	0.005	0.000	0.001	0.001	0.006	0.000	0.151
223	0.084	0.098	0.088	0.046	0.078	0.114	0.019	0.095	0.088	0.106	0.081	0.088	0.005	0.003	0.012	0.003	0.011	0.151	0.000
224	0.114	0.128	0.138	0.048	0.137	0.087	0.005	0.108	0.150	0.143	0.136	0.148	0.003	0.002	0.002	0.002	0.006	0.182	0.123
225	0.096	0.109	0.104	0.016	0.101	0.077	0.006	0.096	0.113	0.116	0.098	0.109	0.002	0.000	0.001	0.001	0.005	0.130	0.100
228	0.110	0.125	0.102	0.023	0.100	0.076	0.003	0.111	0.106	0.130	0.102	0.106	0.002	0.001	0.003	0.001	0.005	0.128	0.101
231	0.022	0.030	0.025	0.018	0.029	0.052	0.012	0.028	0.036	0.028	0.028	0.029	0.000	0.000	0.000	0.000	0.001	0.035	0.073
232	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.023	0.050
234	0.087	0.100	0.135	0.012	0.140	0.093	0.001	0.082	0.144	0.122	0.129	0.149	0.002	0.000	0.001	0.003	0.009	0.178	0.122
235	0.087	0.101	0.099	0.012	0.095	0.071	0.001	0.088	0.105	0.107	0.096	0.108	0.002	0.001	0.001	0.002	0.004	0.123	0.088
236	0.099	0.103	0.086	0.026	0.072	0.067	0.017	0.103	0.084	0.114	0.074	0.078	0.004	0.005	0.012	0.004	0.007	0.097	0.090
237	0.065	0.075	0.081	0.015	0.074	0.076	0.007	0.070	0.084	0.079	0.077	0.083	0.002	0.001	0.001	0.002	0.003	0.103	0.084
239	0.087	0.099	0.094	0.024	0.080	0.068	0.006	0.091	0.101	0.110	0.084	0.091	0.007	0.006	0.002	0.005	0.011	0.112	0.096
242	0.085	0.093	0.120	0.011	0.125	0.084	0.004	0.081	0.130	0.105	0.118	0.138	0.003	0.000	0.001	0.001	0.004	0.152	0.086
244	0.009	0.008	0.004	0.004	0.011	0.004	0.002	0.012	0.004	0.007	0.016	0.005	0.003	0.003	0.003	0.001	0.001	0.006	0.005
245	0.044	0.046	0.034	0.024	0.031	0.034	0.007	0.045	0.036	0.045	0.039	0.036	0.001	0.000	0.005	0.000	0.005	0.042	0.045
246	0.007	0.006	0.006	0.002	0.007	0.006	0.004	0.011	0.004	0.005	0.085	0.012	0.003	0.001	0.003	0.001	0.002	0.007	0.006
249	0.001	0.002	0.003	0.005	0.002	0.004	0.006	0.004	0.002	0.001	0.003	0.002	0.002	0.001	0.003	0.002	0.002	0.003	0.010
250	0.003	0.002	0.001	0.007	0.000	0.004	0.006	0.005	0.001	0.000	0.001	0.000	0.000	0.000	0.003	0.000	0.002	0.002	0.013
251	0.003	0.010	0.003	0.009	0.003	0.009	0.002	0.005	0.005	0.007	0.004	0.004	0.000	0.002	0.005	0.000	0.000	0.004	0.013
253	0.008	0.013	0.006	0.012	0.007	0.033	0.085	0.013	0.014	0.010	0.007	0.008	0.001	0.001	0.001	0.001	0.002	0.015	0.044

	224	225	228	231	232	234	235	236	237	239	242	244	245	246	249	250	251	253
147	0.003	0.002	0.002	0.001	0.000	0.003	0.002	0.005	0.001	0.007	0.001	0.001	0.003	0.000	0.002	0.002	0.000	0.001
148	0.004	0.002	0.003	0.003	0.000	0.003	0.003	0.005	0.003	0.007	0.003	0.002	0.000	0.002	0.002	0.000	0.001	0.002
150	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000	0.000	0.001	0.005	0.000
151	0.003	0.000	0.004	0.007	0.000	0.000	0.001	0.010	0.001	0.005	0.002	0.001	0.002	0.000	0.001	0.001	0.004	0.005
152	0.003	0.002	0.005	0.006	0.000	0.002	0.002	0.007	0.003	0.006	0.001	0.002	0.003	0.001	0.001	0.002	0.001	0.003
153	0.003	0.002	0.003	0.003	0.000	0.003	0.003	0.005	0.002	0.005	0.004	0.005	0.001	0.002	0.002	0.000	0.022	0.001
155	0.005	0.005	0.009	0.008	0.000	0.004	0.006	0.009	0.001	0.011	0.001	0.005	0.010	0.003	0.001	0.001	0.004	0.004
159	0.004	0.003	0.002	0.003	0.000	0.002	0.002	0.003	0.002	0.006	0.001	0.003	0.004	0.003	0.002	0.003	0.002	0.002
161	0.140	0.114	0.125	0.026	0.001	0.112	0.109	0.090	0.078	0.104	0.103	0.017	0.048	0.014	0.001	0.001	0.003	0.007
162	0.139	0.106	0.113	0.220	0.001	0.114	0.100	0.120	0.100	0.133	0.097	0.010	0.048	0.008	0.011	0.013	0.019	0.101
163	0.143	0.110	0.107	0.031	0.001	0.138	0.104	0.081	0.084	0.092	0.123	0.006	0.036	0.008	0.003	0.001	0.002	0.007
165	0.124	0.095	0.105	0.026	0.001	0.125	0.094	0.071	0.074	0.081	0.111	0.031	0.045	0.026	0.005	0.007	0.002	0.006
166	0.119	0.137	0.138	0.033	0.001	0.096	0.093	0.099	0.068	0.099	0.086	0.037	0.070	0.032	0.004	0.001	0.006	0.012
167	0.142	0.102	0.170	0.024	0.001	0.119	0.092	0.098	0.062	0.085	0.103	0.005	0.043	0.002	0.000	0.000	0.004	0.008
169	0.007	0.004	0.007	0.014	0.000	0.002	0.001	0.013	0.006	0.008	0.002	0.001	0.009	0.001	0.002	0.007	0.005	0.010
171	0.010	0.008	0.006	0.019	0.000	0.004	0.002	0.019	0.014	0.012	0.006	0.006	0.006	0.006	0.007	0.008	0.003	0.015
172	0.011	0.010	0.006	0.015	0.000	0.006	0.004	0.013	0.010	0.028	0.006	0.001	0.009	0.001	0.008	0.009	0.002	0.013
173	0.142	0.108	0.105	0.030	0.001	0.136	0.104	0.080	0.083	0.090	0.122	0.007	0.037	0.007	0.009	0.004	0.002	0.009
176	0.010	0.008	0.008	0.010	0.000	0.006	0.004	0.016	0.008	0.015	0.004	0.002	0.066	0.001	0.017	0.008	0.001	0.008
179	0.114	0.096	0.110	0.022	0.001	0.087	0.087	0.099	0.065	0.087	0.085	0.009	0.044	0.007	0.001	0.003	0.003	0.008
182	0.128	0.109	0.125	0.030	0.001	0.100	0.101	0.103	0.075	0.099	0.093	0.008	0.046	0.006	0.002	0.002	0.010	0.013
184	0.138	0.104	0.102	0.025	0.001	0.135	0.099	0.086	0.081	0.094	0.120	0.004	0.034	0.006	0.003	0.001	0.003	0.006
185	0.048	0.016	0.023	0.018	0.000	0.012	0.012	0.026	0.015	0.024	0.011	0.004	0.024	0.002	0.005	0.007	0.009	0.012
187	0.137	0.101	0.100	0.029	0.001	0.140	0.095	0.072	0.074	0.080	0.125	0.011	0.031	0.007	0.002	0.000	0.003	0.007
188	0.087	0.077	0.076	0.052	0.001	0.093	0.071	0.067	0.076	0.068	0.084	0.004	0.034	0.006	0.004	0.004	0.009	0.033
189	0.005	0.006	0.003	0.012	0.000	0.001	0.001	0.017	0.007	0.006	0.004	0.002	0.007	0.004	0.006	0.006	0.002	0.085
190	0.108	0.096	0.111	0.028	0.001	0.082	0.088	0.103	0.070	0.091	0.081	0.012	0.045	0.011	0.004	0.005	0.005	0.013
192	0.150	0.113	0.106	0.036	0.001	0.144	0.105	0.084	0.084	0.101	0.130	0.004	0.036	0.004	0.002	0.001	0.005	0.014
195	0.143	0.116	0.130	0.028	0.001	0.122	0.107	0.114	0.079	0.110	0.105	0.007	0.045	0.005	0.001	0.000	0.007	0.010
196	0.136	0.098	0.102	0.028	0.001	0.129	0.096	0.074	0.077	0.084	0.118	0.016	0.039	0.085	0.003	0.001	0.004	0.007
198	0.148	0.109	0.106	0.029	0.001	0.149	0.108	0.078	0.083	0.091	0.138	0.005	0.036	0.012	0.002	0.000	0.004	0.008
203	0.003	0.002	0.002	0.000	0.000	0.002	0.002	0.004	0.002	0.007	0.003	0.003	0.001	0.003	0.002	0.000	0.000	0.001
204	0.002	0.000	0.001	0.000	0.000	0.000	0.001	0.005	0.001	0.006	0.000	0.003	0.000	0.001	0.001	0.000	0.002	0.001
205	0.002	0.001	0.003	0.000	0.000	0.001	0.001	0.012	0.001	0.002	0.001	0.003	0.005	0.003	0.003	0.003	0.005	0.001
211	0.002	0.001	0.001	0.000	0.000	0.003	0.002	0.004	0.002	0.005	0.001	0.001	0.000	0.001	0.002	0.000	0.000	0.001
212	0.006	0.005	0.005	0.001	0.000	0.009	0.004	0.007	0.003	0.011	0.004	0.001	0.005	0.002	0.002	0.002	0.000	0.002
216	0.182	0.130	0.128	0.035	0.023	0.178	0.123	0.097	0.103	0.112	0.152	0.006	0.042	0.007	0.003	0.002	0.004	0.015
223	0.123	0.100	0.101	0.073	0.050	0.122	0.088	0.090	0.084	0.096	0.086	0.005	0.045	0.006	0.010	0.013	0.013	0.044
224	0.000	0.144	0.141	0.040	0.001	0.165	0.132	0.103	0.094	0.120	0.144	0.010	0.050	0.008	0.003	0.001	0.004	0.010
225	0.144	0.000	0.118	0.023	0.001	0.117	0.110	0.094	0.080	0.101	0.109	0.003	0.040	0.003	0.003	0.005	0.002	0.007
228	0.141	0.118	0.000	0.028	0.001	0.117	0.108	0.110	0.078	0.104	0.104	0.032	0.072	0.030	0.001	0.001	0.007	0.010
231	0.040	0.023	0.028	0.000	0.002	0.041	0.023	0.031	0.040	0.028	0.029	0.000	0.015	0.000	0.004	0.003	0.007	0.144
232	0.001	0.001	0.001	0.002	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
234	0.165	0.117	0.117	0.041	0.002	0.000	0.114	0.082	0.088	0.097	0.144	0.005	0.040	0.005	0.001	0.002	0.007	0.011
235	0.132	0.110	0.108	0.023	0.001	0.114	0.000	0.083	0.075	0.097	0.106	0.005	0.041	0.004	0.001	0.001	0.001	0.005
236	0.103	0.094	0.110	0.031	0.001	0.082	0.083	0.000	0.067	0.103	0.078	0.008	0.045	0.006	0.003	0.004	0.007	0.017
237	0.094	0.080	0.078	0.040	0.001	0.088	0.075	0.067	0.000	0.074	0.082	0.003	0.033	0.003	0.003	0.001	0.003	0.025
239	0.120	0.101	0.104	0.028	0.001	0.097	0.097	0.103	0.074	0.000	0.089	0.007	0.041	0.005	0.003	0.001	0.003	0.011
242	0.144	0.109	0.104	0.029	0.001	0.144	0.106	0.078	0.082	0.089	0.000	0.004	0.036	0.005	0.001	0.002	0.001	0.007
244	0.010	0.003	0.032	0.000	0.000	0.005	0.005	0.008	0.003	0.007	0.004	0.000	0.045	0.073	0.002	0.001	0.002	0.001
245	0.050	0.040	0.072	0.015	0.000	0.040	0.041	0.045	0.033	0.041	0.036	0.045	0.000	0.042	0.009	0.004	0.005	0.007
246	0.008	0.003	0.030	0.000	0.000	0.005	0.004	0.006	0.003	0.005	0.005	0.073	0.042	0.000	0.003	0.000	0.008	0.001
249	0.003	0.003	0.001	0.004	0.000	0.001	0.001	0.003	0.003	0.003	0.001	0.002	0.009	0.003	0.000	0.044	0.002	0.002
250	0.001	0.005	0.001	0.003	0.000	0.002	0.001	0.004	0.001	0.001	0.002	0.001	0.004	0.000	0.044	0.000	0.000	0.002
251	0.004	0.002	0.007	0.007	0.000	0.007	0.001	0.007	0.003	0.003	0.001	0.002	0.005	0.008	0.002	0.000	0.000	0.019
253	0.010	0.007	0.010	0.144	0.000	0.011	0.005	0.017	0.025	0.011	0.007	0.001	0.007	0.001	0.002	0.002	0.019	0.000

Figure 7: Mutual Friend Percentage Matrix

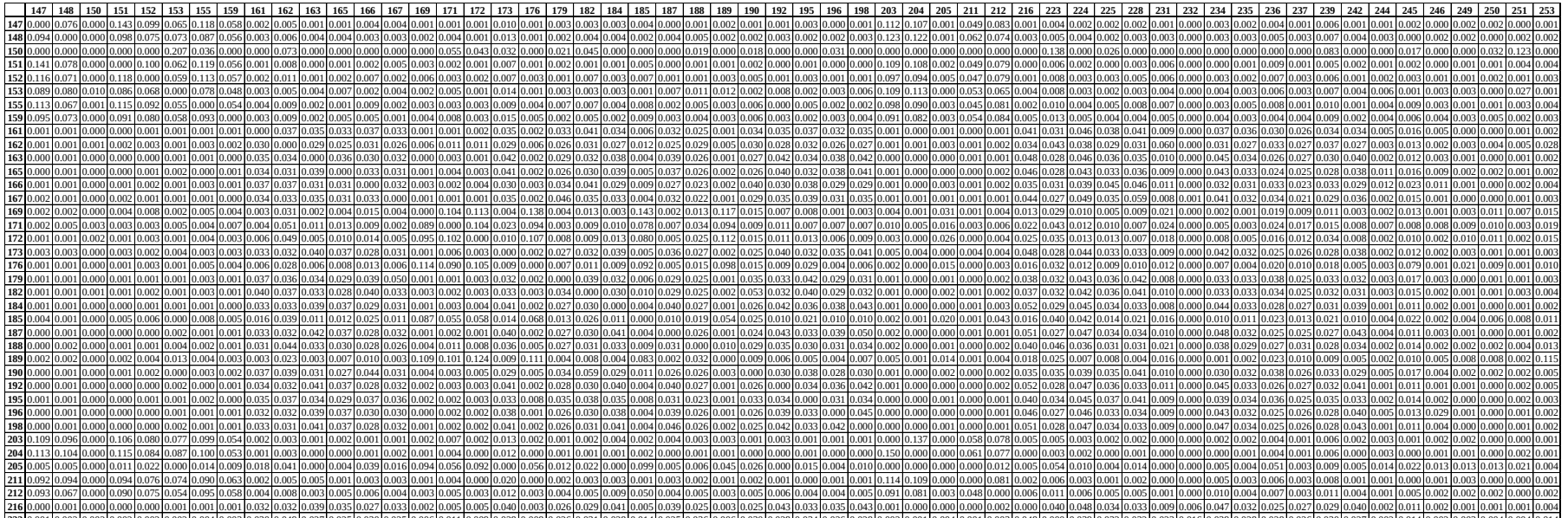


Figure 8: Mutual Friend Percentage Matrix – Row Standardized

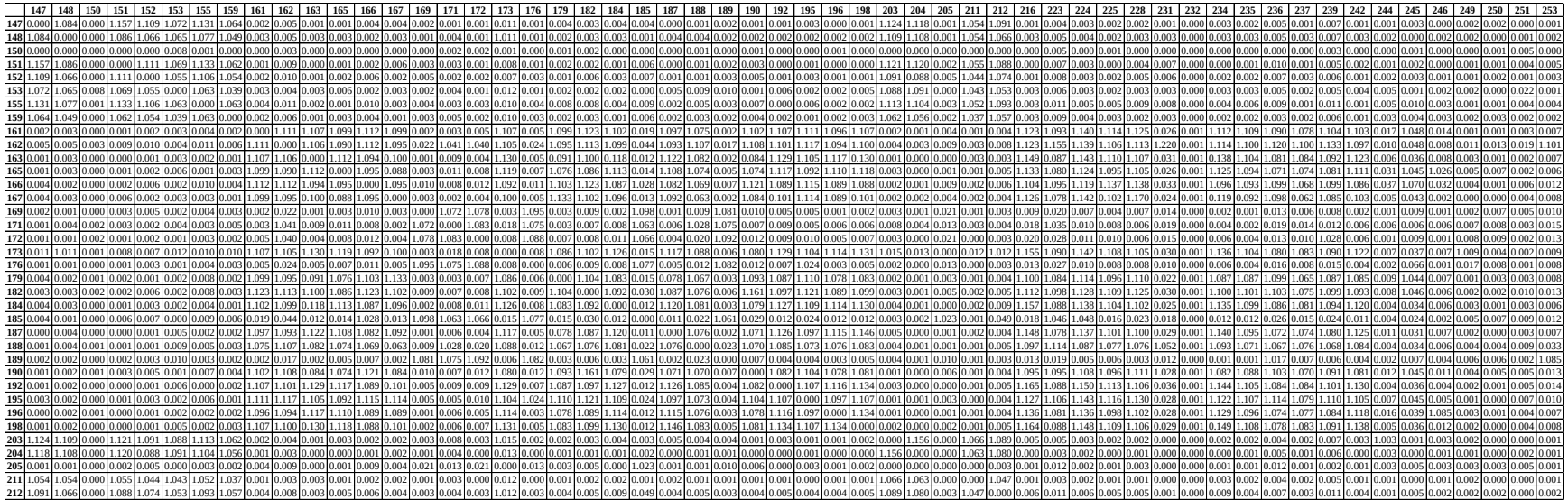


Figure 9: Direct and Mutual Matrix

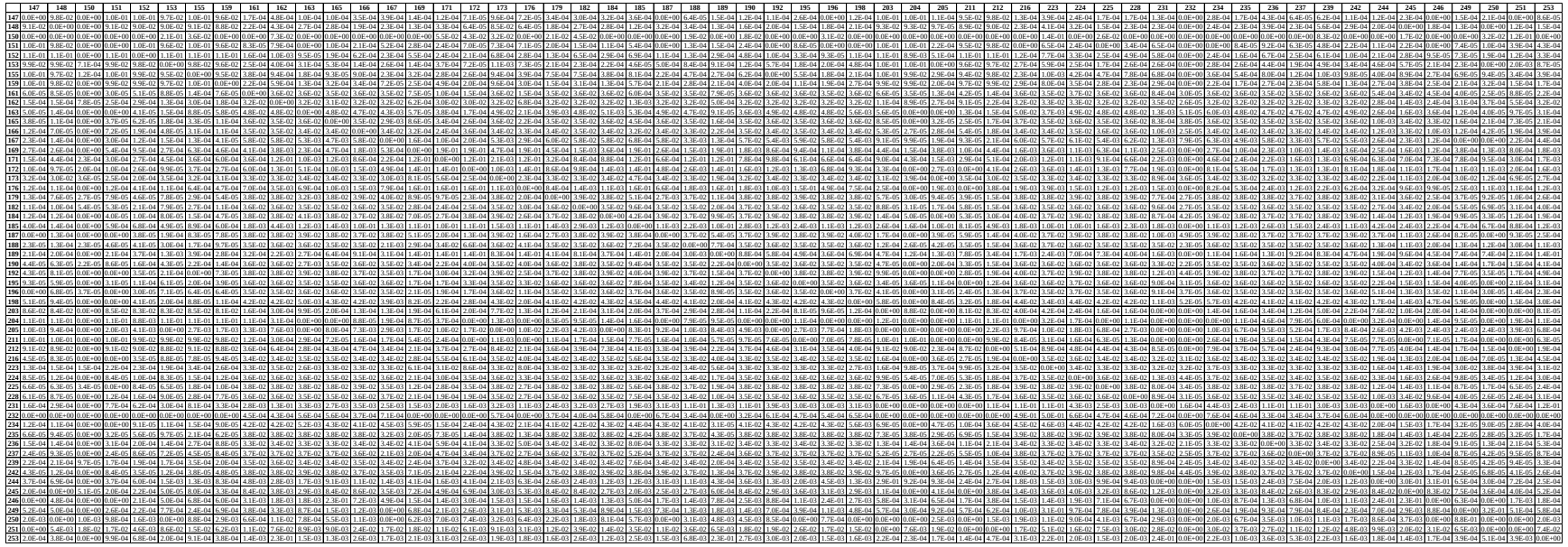


Figure 10: Direct and Mutual Matrix – Row Standardized

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